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## Forthcoming Events.

JANUARY 8.

*Institute of Metals (Birmingham Local Section)*:—Ordinary meeting at Birmingham. "Nickel Brasses," Paper by O. Smalley.

*Institute of Metals (North-East Coast Local Section)*:—Ordinary meeting at Newcastle-on-Tyne. "The Action of Molten Brass on Nickel-Steel," Paper by H. M. Duncan, B.Sc.

JANUARY 10.

*Institute of Metals (London Local Section)*:—Ordinary meeting in London. "X-rays and Metallurgy," Paper by W. F. Griffiths.

*Institution of British Foundrymen (Birmingham Branch)*:—Ordinary meeting at Birmingham. "Ferrous Slags and Fluxes," Paper by J. E. Fletcher.

JANUARY 11.

*Institute of British Foundrymen (Sheffield Branch)*:—Conjoint meeting at Sheffield, with Institute of Metals. "Influence of Casting Temperature on the Physical Properties of Metals," Paper by F. H. Hurren, A.I.C.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

*Institute of British Foundrymen.*

PRESIDENT, 1923-24, Oliver Stubbs, M.I.Mech.E., Openshaw, Manchester.

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West Ridings of Yorkshire Branch: A. Love, 232, Gladstone Street, Bradford.

*Welsh Engineers' and Founders' Association.*

Secretary: E. J. Griffiths. 20, Fisher Street, Swansea.

## Introspective, 1924.

"It is unlikely that 1924 will be any worse than 1923." This was the answer given by one of Great Britain's foremost industrial magnates to our query as to the possibility of foundry trade conditions improving, and probably represents the general concensus of opinion. The orders given by the railway companies are neutralising very largely any slump which the present unstable political situation might have introduced. This, however, is only partial in its effect on the foundry trades taken as a whole. It does not affect the textile shops, light castings concerns, or the purely marine engineering foundries. The automobile foundries start this year in a much healthier condition than last, but this trade has developed into a seasonal one, the Motor Show being an important influencing factor.

The foundries catering for the building trades are likely to be handicapped in domestic business by the shortage of bricklayers and other skilled artisans, which factor is likely to limit extensive progress. However, business is likely to remain steady so far as the home market is concerned. Another important factor which is still having an influence on the future is the shortage of coke, which undoubtedly will continue to make the lighting of many additional blast furnaces a difficult problem.

The forecasting of trade conditions for the foundry industry is really anticipating general industrial conditions, which question is so allied to international and domestic political and economical considerations, that we prefer to leave the subject to that section of the Press making a speciality of it.

Technically, this year promises to be rather quieter than that which has just closed owing to the absence of an international congress. The Annual Conference of the Institute of British Foundrymen is to be held in Newcastle, and already preparations are well in hand to make this an outstanding success. Under the guidance of Messrs. R. O. Patterson, James Smith and H. A. J Rang, foundrymen can be assured in advance that every effort will be made to ensure that the high standard now established for these functions will be more than maintained. There will, in all probability, be two exhibitions of interest for foundrymen. Primarily, there is the British Empire Exhibition at Wembley, which is to contain many foundry exhibits, and in addition the Birmingham Chamber of Commerce will probably stage their second International Foundry Exhibition. Early in June there is to be a Mining and Metallurgical Conference in connection with the British Empire Exhibition, and many foundrymen would like to see their national technical organisation represented.

The international exchange of technical papers by the Institute with the American Foundrymen's Association and the Association Technique de Fonderie, which has proved to be an excellent innovation, will be continued. The system has shown itself to be so beneficial that other technical and scientific organisations would do well to adopt it.

Of particular foundry developments we can confidently predict the further introduction of moulding machines for a wider range of production jobs, as prejudice is being rapidly dissipated. An early attempt is anticipated to introduce some radical changes in cupola plant, incorporating the application of old principles on new lines. More detailed study is to be given to the provision of better ladles of more varied design for foundry practice, some of which promise to be revolutionary in character.

XUM

# Correspondence.

*[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]*

### Transverse Test Bars in India.

*To the Editor of* THE FOUNDRY TRADE JOURNAL.

Sir,—For a number of years specifications for iron castings manufactured in India have carried the usual clause relating to test bars. These specifications were submitted originally through the Public Works Department. Since the British Standard Specification was evolved, this has been adopted on the classes of work covered by it.

The inspection of castings included, in a very large works, a daily routine of breaking transverse test bars representing certain classes of castings other than pipes. These were giving exceptionally high results, often more than 35 cwts., and frequently were not broken after the application of a load of 40 cwts. associated with a ½-in. deflection.

A glance at the analysis book suggested this was due to a high manganese content, but a close investigation of the fracture revealed a decided chill extending a full 1-16th in. from each edge of the bar.

The cause was eventually proved to originate in the foundry *personnel* taking advantage of opportunities for doubtful practice.

The necessity then arose for stamping each mould, supervising the pouring of the castings, and the taking of other precautions for preventing similar occurrences.

The system adopted was to cast two bars in each box using a single runner, but with a separate riser on each bar. They were cast on edge in a green-sand mould. The results were discouraging, the bars only giving a daily average of 25 cwts.

Transverse test bars representing pipes and specials made to the British Standard Specification frequently show, when tested as specified, considerable discrepancies. It is well known that, in the great metallurgical countries, such test bars can give very erratic results, and the writer finds that Indian iron can safely be classed in the same category.

India has not yet considered the necessity of investigating the scientific side of iron founding, and consequently quite a number of foundries are isolated and neglected, and regarded as a necessary evil. At a concern recently visited by the writer, the cupolas were not equipped with blast gauges, and the weighing machines were frequently out of order for months on end; actually, in one department recently fitted with new plant to produce 60 tons of castings per day, the weighing machine was entirely absent. Further, the labour is such that, where a weighing machine is installed, the list of charge weights may be written down at a moment's notice at any hour of the day—from memory! This, of course, is a question of mismanagement.

Under such conditions no other result with regard to test bars is to be expected, and until such time as the management concerned assist the foundryman to get improved results, the position will remain in its present chaotic condition.

It is generally conceded that test bars do not represent the casting; if this were not so, the foundries would be providing a rod for their own back in producing questionable castings which might fail in the future and introduce serious calamities.

A well-known consulting engineer in England recently stated, when asked "Why do you still insist on test bars in your specifications?" that: "It is the practice generally to do so. This has been the procedure for 100 years or more."

As the foundry trade is now seeking light on many things, is there no one on the various committees who will urge that transverse test bars be dispensed with entirely? If they do not represent the casting, why make them?

No doubt many castings in years gone by have passed inspection by the aid of faked test bars, and done their duty in their different spheres satisfactorily, which certainly suggests that the transverse test bar is a negligible quantity.

During trade depression it is difficult for any firm to withstand financial losses due to test bar failures, with an easy conscience. Whilst a casting may stand a suitable physical test applied, it is still open to rejection if the test bar fails.

It would be a boon to foundrymen generally if this test was withdrawn, even temporarily, until such time as the B.C.I.R.A. had completed their investigations of a practical nature. Possibly a number of members' firms would be very glad to subscribe, say, 20 test bars each, giving full data relating to them, for investigation and comparison, with any recommendations they cared to make.

Assuming that such investigation proved successful in reducing to a minimum their erratic behaviour, then it is suggested that this type of test bar should be reinstated only where its value is proved.

There is no doubt about the uneasy feeling experienced by the manufacturer when material is subject to the transverse test bar specification. A recent case came to the writer's notice where a business proposition was turned down because 32-cwt. test bars were required.

The suggested universal test bar is creating considerable thought and debate in foundry circles, and India would appreciate any opinions expressed by the leading authorities as to the possibility of eliminating entirely the transverse test bar from specifications.

Finally, there appears to be quite an interesting amount of work for the B.C.I.R.A. in India, when they are in the position of being able to extend their assistance beyond the United Kingdom.—Yours, etc.,

H. LEWIN.
Inspector of Castings, E.I. Railways.
Kulti, India.
December 3, 1923.

[It is easy to suggest the abandoning of the transverse test, but all substituted tests suffer from exactly the same inherent faults, which are ascribable to the nature of cast iron, rather than to the test. Surely, the correct course to pursue is to standardise existing tests so as to eliminate as many variables as possible.—ED.]

### Briquetting of Cast-iron Borings.

*To the Editor of* THE FOUNDRY TRADE JOURNAL.

SIR,—I read with deep interest the editorial of your issue of December 13, 1923, on the "Utilisation of Turnings," and most particularly your reference to my Paper on "The Briquetting and Use of Cast-Iron Borings and Turnings."

Your kindly and, I might say, constructive criticism is much appreciated, yet I feel that I cannot allow your remarks with regard to my "metallurgical conclusions" to pass quite unchallenged.

I am not aware of having come to any conclusion such as is suggested. The point I tried to emphasise with regard to clay water was, as you indicate, primarily "more mechanical," and your visualisation of "several square miles of surface being exposed to oxidisation" is quite in line with my own ideas. This point I stressed fairly well when I indicated the rise in temperature of about 60 deg. Fah. in the briquette consequent upon leaving the briquetting machine. A portion of the power applied in compressing the briquetted mass will, by conservation of energy, be transformed into heat, resulting in a slight internal warming of the briquette. Such a rise in temperature will naturally accelerate chemical action and so effect a further rise in temperature, resulting in the "steaming of the briquette" which I indicated in my Paper.

This chemical action will essentially be the superficial oxidation of the particles of the mass. To carry this to a logical conclusion, the oxide of iron thus formed will be in most intimate contact with the respective surfaces of the iron particles and form a natural and efficient ferruginous bond. I think you will agree with me, however, that no matter how well a briquette is compressed absolutely intimate contact between the particles of the mass can never be obtained. Therefore, in so far as bonding is concerned, the clay must form a very efficient connecting link between several ferruginous coatings of the iron particles, thus filling up the already indicated interstices.

Water alone has been tried, as have several other commodities, but without the success which has attended the use of clay water. As I indicated, with all other substances, the press frictions badly, grunting heavily, particularly during the last stages of the squeeze. And as a finished commodity, I find that there is no comparison between a briquette made with water alone and one made with clay water.

With regard to my friend Mr. Arnott's remarks in your issue of December 20, I would indicate that my reason for casting a 50 per cent. briquette mixture was really to prove the process and not for the purpose of establishing such a high admixture of briquettes as a regular practice. I think that where statistics are available that somewhere about 5.5 per cent. of the initial weight of the castings will appear as the by-product called borings and turnings Carrying this further, and to put a figure on it, 4 per cent. will in an all-round way represent the proportions of these borings and turnings to the total iron melted necessary to produce these castings.

Call it 5 per cent., and so if the briquetting process is consistently employed, seldom if ever would the briquette proportion of the cupola charges be greater than 5 per cent. Correspondingly, the additional sulphur content to which my friend takes exception, and which, so far, seems a refgretably inherent concomitant of the process, would be only one-tenth of that which I indicate was the augmentation in the 50 per cent. mixture. Again, is it not the case that what was known as the "sulphur bogey" has by now more or less ceased to exist. Some foundrymen actually preferring an iron with a reasonably high sulphur content and judiciously handling it.

The mechanical tests of 37 cwt. and 0.432 ins. deflection on a 2 in. by 1 in. by 36 in. centre bars indicate no material disability through the 0.153 per cent. sulphur content, and surely such an iron is worth £6 per ton.

With regard to the price of borings, this is a very vexed question. It is not so long ago that it was difficult in some localities to obtain 10s. per ton for them, and as you, Sir, indicate, payment had to be made in other localities for their removal. At present the prices here and there may be up to a reasonable figure, but when by-products can be efficiently handled, when and where they are produced, surely we have the maximum of efficiency.—Yours, etc.,

J. ALEX. GARDNER.

24, South Hamilton Street,
Kilmarnock.
December 26, 1923.

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### Cost of Castings.

*To the Editor of* THE FOUNDRY TRADES JOURNAL.

SIR,—One of the basic reasons for the present trouble in the London foundry industry is that the production of a skilled trade and a key industry is being sold by the cwt. similarly to coal or potatoes. A timber merchant does not sell a quantity of floorboards or matchboards by weight, but at so much per foot or square yard. A carpenter or patternmaker will supply his produce based on value of timber and *cost of production*. Most engineers will base their lathe work, etc., on cost of labour, at so much per hour per man.

Many years ago many patterns were sent to foundries and castings were produced and charged according to cost of production and the weight of material used. Those days have passed away, in spite of foundrymen having seen the folly of making castings by weight, and they are submitting to the buyers prices which they know are doubtful. The buyer cannot very well lose under such conditions, and generally he does not realise the difficulties to be met in the foundry through estimating for all classes of work by weight alone.

In a general jobbing foundry making castings for perhaps dozens of different customers in one day, it often happens that an arrangement has been made after inspecting the types of casting a customer requires (varying from large and light, through medium and heavy to very light) an all-round price is given. But experience has shown that a great proportion of light castings are ordered, and eventually the foundry manager finds he is losing money for his firm, and only too often learns much to his disgust that the larger and heavier work is going elsewhere at a still lower rate. This kind of business is detrimental to the foundry trade generally.

During the war foundries had orders to make shells, fuses, bombs, grenades, etc., at a price for each article. Why should a founder supply cast-iron motor cylinders, pistons, and the various iron castings which help to make up a complete car, which is sold for so many pounds according to its *value* and not weight. It is seldom found that an engineer offers the foundrymen an extra 5s. per cwt. when complicating a pattern; he merely remarks: "It is not much more work," but the extra work is decreasing the value per cwt. to the foundryman. The above does not only apply to iron castings, it is exactly the same with non-ferrous foundries.

At the present time the ruling prices are ridiculous when compared with those of the various materials used.

Taking the value of iron, it is found that a customer will often complain if charged 4d. per lb. for small iron castings and yet he will pay 1s. 2d. per lb. for gunmetal castings, but will not agree to pay more than 2s. per lb. for aluminium, which metal is roughly about one-third the weight of gunmetal, no small wonder people prefer to use aluminium wherever possible.

Large quantities of aluminium castings are being moulded to-day on machines, and if the value of those castings was paid for in comparison to gunmetal a much higher price would be charged.

It is not necessary for the writer to give prices of the various metals to show the disparity between the different prices for various metals, as most foundrymen know the prices. The writer does not advocate rings or combines to fix prices, but the time has arrived when the foundry owners should put the house in order.

Better castings are being demanded every day, and better quality can be given when a mechanic is given work that will interest him, and not work that will cause him to wonder what the foreman will say if the casting only weighs half cwt. and he has spent some hours on the job. Is it to be expected that one can find apprentices under such conditions for the foundry? Foundrymen realise what it means to estimate from Blue Prints, and how easy it is to underestimate or overestimate the weight. The moulding time may be as estimated, and yet the price received does not tally with the estimate. If the price quoted had been taken on cast of moulding, the difference in weight of material would not make the same difference of loss or gain to the foundryman.

Any ordinarily equipped jobbing foundry would invariably prefer heavy machinery castings, because the weight lowers the cost of production. Why should the engineer pay treble the price for heavy machinery castings than he would for lighter castings? That is the opinion of the buyer.

If the foundryman could convince the buyer that the article supplied should be based on its production value as most other manufactured articles in the engineering trade are sold, better castings could be supplied. The selling price would be placed on the right article instead of a spread-over system, which has developed very rapidly since the War, that it has become difficult for a foundry owner to know what is paying him and what is not.—Yours, etc.,

A LONDON FOUNDRY MANAGER.

Croydon, December 27.

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## Foundry Queries.

### Facing Sand for Ornamental Castings.

I should esteem it a favour if any reader could indicate the best method of procuring a good, fine face on ornamental castings made in brass or gunmetal, pointing out the type and source of supply of suitable sand. Information relative to the best way of moulding and drying would also be welcome.

G. A.

## Trade Talk.

THE GLACIER METAL COMPANY, LIMITED, have removed to Ealing Road, Alperton, Wembley.

THE LIVERPOOL OFFICE of Fredk. Braby & Company, Limited, has been removed to 71, Vauxhall Road, Liverpool.

A LICENCE under the Non-Ferrous Metal Industry Act, 1918, has been granted by the Board of Trade to W. G. Keen & Company, 11, Small Street, Bristol.

JOSEPH EVANS & SONS (WOLVERHAMPTON), LIMITED, have removed their London offices from Salisbury House, London Wall, to Craven House, Kingsway, W.C.2.

MR. JAMES W. HALL, St. Mary Abchurch House, 123, Cannon Street, E.C.4, has transferred his office to the Switchgear Works, Gander Green Lane, Sutton, Surrey.

SUFFOLK IRON FOUNDRY (1920), LIMITED, Gipping Works, Stowmarket, have recently placed a contract with the Chatteris Engineering Company, Limited, for a 7-ton 3-motor electric crane.

NEWTONS, LTD., manufacturing electrical engineers, of Rowbarton, Taunton, are transferring their London sales department from Victoria Road, Willesden Junction, N.W.10, to their Taunton works.

MR. M. SPITZER, of 16, Devonshire Square, London, E.C.2, has been appointed agent in the United Kingdom by G. Dumont et Freres, of Leige, for the sale of their lead pipes and sheets and zinc sheets.

MR. H. E. MAYHEW, iron and steel merchant, 5, Billiter Buildings, Billiter Street, London, E.C.3, has been appointed London representative for the Birchley Rolling Mills, Limited, of Oldbury, and J. B. & S. Lees, Limited, Albion Iron and Steel Works, West Bromwich.

WELDRICS (1922), LIMITED, Bush Lane House, Cannon Street, London, E.C.4, have acquired the business of T. Scott Anderson, engineers and welding specialists, Royal Insurance Buildings, Church Street, Sheffield, where the business will be carried on as a branch establishment of the former firm.

MR. H. R. SUMMERS has vacated the secretaryship of the British Engineers' Association, and is joining the board of Research and Development, Limited, whose offices are at present at 25, Bedford Street, Strand, London, W.C. The company will be moving shortly to larger premises to accommodate several of the subsidiary companies it has formed.

JOHN BOWLING & COMPANY, LIMITED, of the Union Foundry, Armley Road, Leeds, have acquired as a going concern the old-established firm of C. H. Taylor & Son, Limited, of Cyclops Foundry, Kirkstall Road, Leeds. The purchase includes the premises, plant, patterns and good-will. Messrs. Taylors were established more than 70 years ago, and enjoy a wide reputation as builders' ironfounders. The works will be carried on at the same address under new management, and under the title of C. H. Taylor & Son.

DR. MOORE, of the Royal Arsenal at Woolwich, lectured recently to students in metallurgy in the Technical School, Sheffield, on the ball hardness test. In the absence through illness of the president, Mr. C. K. Everitt, the chair was taken by Dr. Desch. This was the annual meeting of the Metallurgical Society, and the officers were elected as follow: President, Mr. C. K. Everitt (second year); vice-presidents, Mr. S. E. Howell, Mr. A. J. Capron, Mr. Cosmo Johns, Mr. E. H. Saniter, Mr. J. B. Crosbie; treasurer, Mr. F. K. Knowles; secretary, Mr. E. J. Thackeray.

THE ORDERS PLACED by the London, Midland and Scottish Railway Company, as briefly mentioned in recent issues, include 150 locomotive boilers, 5,000 wagons, and 127,000 tons of steel rails. Seventy of the boilers have been ordered from Vickers, Limited, 50 from the Vulcan Foundry, Limited, and 30 from Kerr, Stuart & Company, Limited. Of the wagons, 1,000 are to be 12-ton steel frame merchandise wagons, the orders for which have been divided as follow: Metropolitan Carriage, Wagon and Finance Company, Limited, 500; G. R. Turner, Limited, 250; Midland Railway Carriage and Wagon Company, Limited, 250. The remaining 4,000 are to be 12-ton mineral wagons, to be built by the following firms: Stableford & Company, Limited, 175; Metropolitan Carriage, Wagon and Finance Company, Limited, 500; Midland Railway Carriage and Wagon Company, Limited, 250; Harrison & Camm, Limited, 100; Gloucester Railway Carriage and Wagon Company, Limited, 225; Hurst, Nelson & Company, Limited, 400; Cravens Railway Carriage and Wagon Company, Limited, 250; Clayton Wagons, Limited, 250; R. Y. Pickering & Company, Limited, 350; Chas. Roberts & Company, Limited, 250; S. J. Claye, Limited, 250; Kerr Stuart & Company, Limited, 250; Hamilton Wagon Company, 200; Ince Wagon and Iron Works Company, Limited, 150; Chorley Wagon and Repairing Company, Limited, 150; and Hall, Lewis & Company, 250.

A SALE OF PLANTS, ETC., has been concluded at the Ordnance Works, Sheffield, of J. & P. Hill. Amongst the highest prices realised were £180 for a Richle steel-testing machine, £320 for a high-speed planing machine (French make), with slotted table, 11 ft. 6 in. x 2 ft. 6 in., but a similar machine made only £275; £160 was the price paid for a double spindle "Niles" boring mill. A self-contained grinding machine, with 5 ft. 6 in. swivel table, by the London Machine Company, was knocked down at £170. A 9 in. centre capstan and turret lathe, 7 ft. 6 in., by the Centaur Tool Company, made £67; two similar lathes by Willson fetched £40 and £43 10s.; £46 was paid for a shaping and slotting machine with 4 in. and 7 in. strokes by Herberts; a shaping machine with slotted bed, 14 in. by 14 in., £36; the No 3 Brown & Sharpe's Universal milling machine, £42; a heavy planing machine with slotted table 12 ft. x 3 ft. 6 in., £60; a radial drill, with 4 ft. 6 in. x 3 ft. 6 in. slotted table, by Hills, £111.

## Calendars, etc., Received.

We have received calendars from **Messrs. E. & W. H. Haley, Limited**, the New Foundry, Listerhills, Thornton Road, Bradford, manufacturers of cast iron pipes and general castings; **Messrs. Crossley Brothers, Limited**, Openshaw, Manchester, makers of oil engines, gas engines and gas plants; **Messrs. Grandidge & Mansergh, Limited**, Wheatley Street, Salford, foundry supply manufacturers and merchants; **Messrs. J. H. Sankey & Son, Limited**, Essex Wharf, Canning Town, London, E.16, makers of tumbling barrels; **The McLain System, Inc.**, Goldsmith Building, Milwaukee, U.S.A., Foundry Correspondence Course.

**Messrs. S. W. B. Stephen & Company**, Smethwick, coal factors and colliery agents; **Mr. H. A. J. Rang**, engineer, steel and iron merchant, 2, St. Nicholas Buildings, Newcastle-on-Tyne.

Diaries for 1924 have been received from the foundry department of **The Staveley Coal & Iron Company, Limited**, Staveley Works, near Chesterfield; **Messrs. Watsons (Metallurgists), Limited**, Lancaster Street, Neepsend, Sheffield, foundry alloy merchants and electric furnace designers; **Messrs. J. Stone & Company, Limited**, Deptford, non-ferrous foundries; **Messrs. British & Continental Traders, Limited**, Brownlow House, 50-51, High Holborn, London, W.C.1., pig-iron merchants, etc. (This diary contains much useful foundry data.)

## Workmen's Compensation Changes.

The Workmen's Compensation Act, 1923, which came into force on January 1, 1924, and introduces many important changes in the law, contains certain new requirements which occupiers of factories, workshops, and other works coming under the Factory and Workshop Acts will be called upon to carry out at once or which otherwise are of special interest to them. Copies of the Summary as prescribed, in placard form, may be obtained on application (either directly or through any bookseller) to H.M. Stationery Office, Imperial House, Kingsway, London, W.C.2; York Street, Manchester; 1, St. Andrew's Crescent, Cardiff; or 120, George Street, Edinburgh; price 1d. each (by post 1½d.).

**Italo-Canadian Commercial Convention.**—The Italian Chamber has passed the Bill for the ratification of the Commercial and Customs Convention between Italy and Canada signed in London on January 4 last.

**Synthetic Foundry Iron.**—The feasibility of producing a good grade of foundry iron from steel scrap in the electric furnace has been demonstrated in experimental work carried out by the U.S. Bureau of Mines at Seattle, Wash. This development permits any manufacturing plant to use up all its iron scrap on the spot in making castings equal to, if not better, than those from cupola iron. Improved methods of charging the 300-lb. experimental furnace used by the Bureau gave more rapid carburisation, and carbon contents as high as 5 per cent. were reached. Several heats were made in a 1-ton commercial electric furnace of the Héroult type, at Hoquiam, Wash., and in a 1-ton indirect-arc, rocking furnace in a foundry at Detroit, Mich. In every case these tests were successful in producing sound, strong, grey iron from steel scrap and iron turnings.

# The Elimination of Structural Weaknesses in Castings.*

By O. Smalley, M.I.Brit.F.

This Paper treats structural weaknesses in castings in relation to the nature of crystallisation of the alloy on solidification and the design of the casting.

### Alloys.

The fundamental factors governing the physical properties of all metals and alloys are composition and structure. In practice these factors are not simply interpreted, being complicated by such external agents as occluded gases, impurities, temperature and time, the influences of which are incompletely understood.

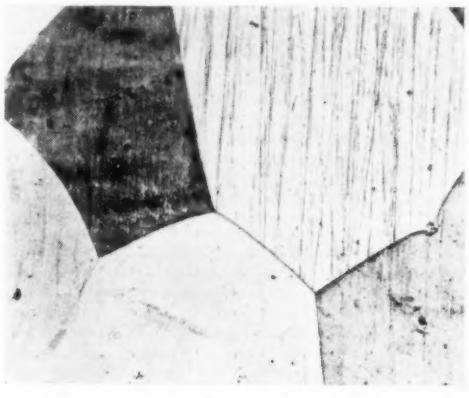
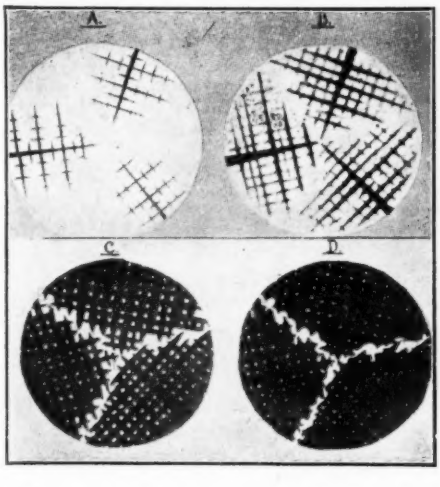


FIG. 1.—HIGH TENACITY BETA BRONZE.

### Genesis of Structure.

Metals and alloys, like minerals, are the products of crystallisation of a liquid solution, and the size of the individual grains is a function of the length of time taken during solidification, the nature of the material and its purity.

Alloys may be sub-divided into two classes:—(1) Those which freeze at one specific temperature or through a short range of temperatures; and (2) those which freeze through an extended range of temperatures.




FIGS. 2 TO 5.—SHOWING THE GROWTH OF CRYSTALLITES IN METALS.

The origin of each crystal grain of alloys of Class 1 appears to be its centre, whence it develops in a regular manner, its orientation determined by the crystallographic system to which it belongs, the last particle of metal freezing at the same temperature as the first (Fig. 1). Such alloys are homogeneous throughout, and possess unit degree of solidity, which in ordinary practice is little affected by temperature and time influences.

When an alloy freezes through a range of temperatures the crystal grain appears to develop from within. Solidification being progressive, the high melting point materials fall out of solution along the axes of the crystal system, and give a skeleton outline of what is termed the primary crystal grain. This progressive development is best followed by reference to Figs. 2—5, a diagram produced by the late Dr. Stead. Fig. 6 illustrates an actual bunch of crystallites taken from the pipe of a large steel casting when insufficient metal remained to feed the interstices of the skeletal framework of the primary crystal grains.

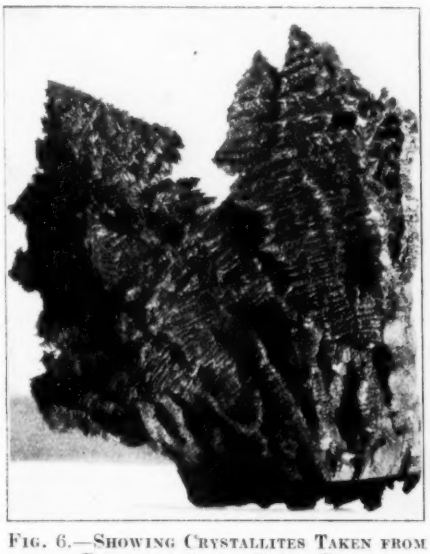


FIG. 6.—SHOWING CRYSTALLITES TAKEN FROM THE PIPE OF A LARGE STEEL CASTING.

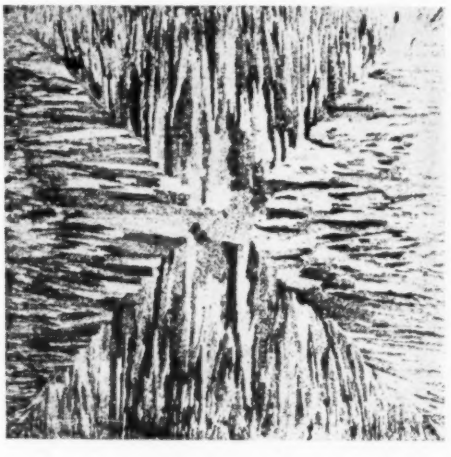


FIG. 7.—SHOWING COLUMNAR CRYSTALS ACROSS A SECTION OF THE CASTING.

Because of such progressive crystallisation, alloys of this class are subject to defects of crystallisation and liquation not encountered in alloys of Class I, and the crystal grains themselves are often heterogeneous. The extent to which these structural weaknesses manifest themselves depend naturally upon *the range of temperature through which the alloy freezes, the alloying properties of the constituents, the temperature, rate of pouring and the rate of cooling* during solidification.

### Alloys of Class I.

The alloys representative of this class are those of eutectic composition, inter-metallic compounds and some special alloys having an exceedingly

* A Paper presented before the West Riding of Yorkshire Branch of the Institute of British Foundrymen.

short freezing range, such as alpha-beta brasses, high tenacity beta brasses, aluminium bronzes and mild steel. Of these, attention will be confined to high tenacity beta brass and to aluminium bronze to show that, given an isomorphic alloy of homogeneous texture, the mechanical properties of a casting depend upon the size, orientation and contour of the crystal grains. It is characteristic, however, of crystal grains of an isomorphous mixture of metals to develop faster in one direction than in another, and the extent to which such unbalanced crystals form is not only a function of the nature of the metal and its purity, but also of *temperature of pouring and rate of cooling.*

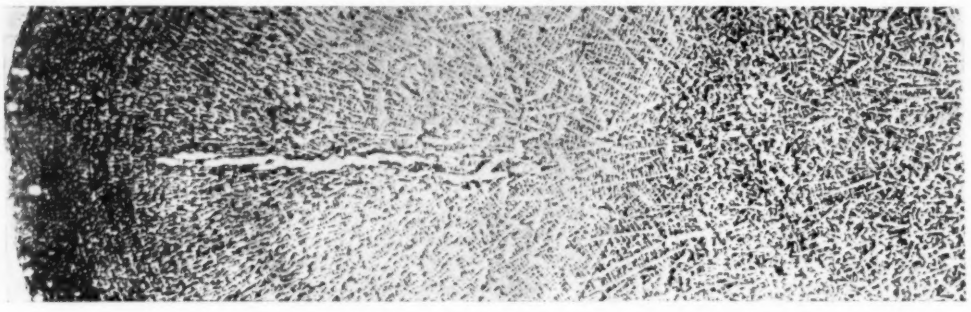


FIG. 8.—ILLUSTRATING HOW ADHESION BETWEEN CRYSTAL BOUNDARIES MAY BE SO LOOSE AS TO SHOW CRACKS.

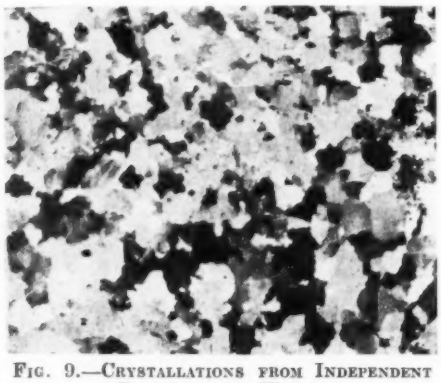


FIG. 9.—CRYSTALLATIONS FROM INDEPENDENT CENTRES FROM WITHIN.

The two alloys under consideration are no exception to the rule, and the physical properties of castings—assuming correct melting conditions—are influenced by (1) the temperature of pouring; (2) the rate of cooling; and (3) its dimension and form. The higher the temperature of pouring the greater the tendency to develop unequiaxed crystals, and by pouring sufficiently hot it is possible to grow columnar crystals across the section of the casting (Fig. 7). Developing at right angles from the plane of cooling surface, they interfere along a plane of junction, and a sharp boundary is formed where there is little or no cohesion, whilst the crystals themselves, separated by smooth, straight boundaries and often by films of gas or impurities, are easily separated (Fig. 8).

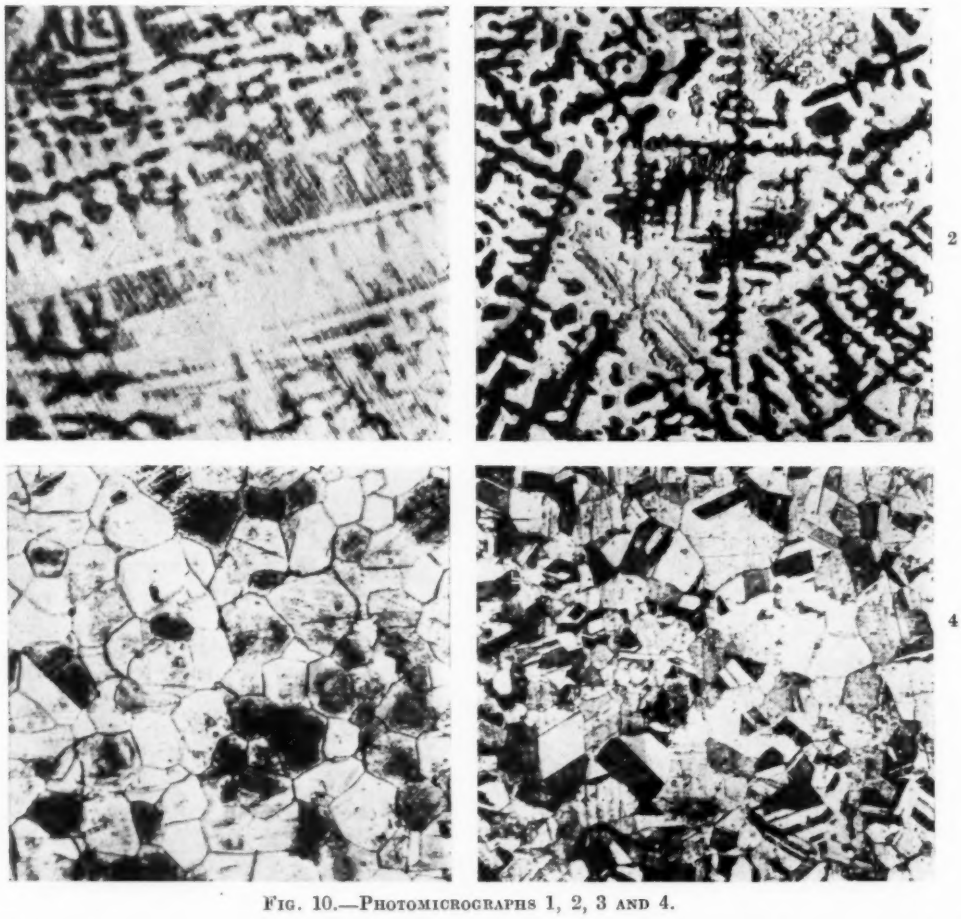
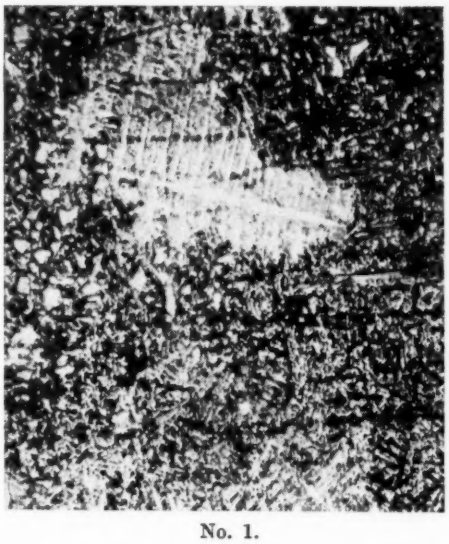
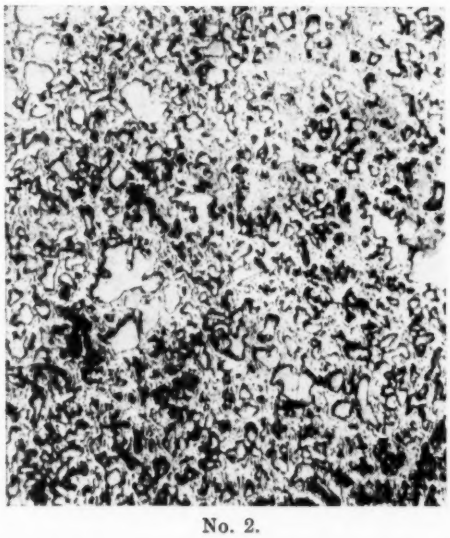



FIG. 10.—PHOTOMICROGRAPHS 1, 2, 3 AND 4.

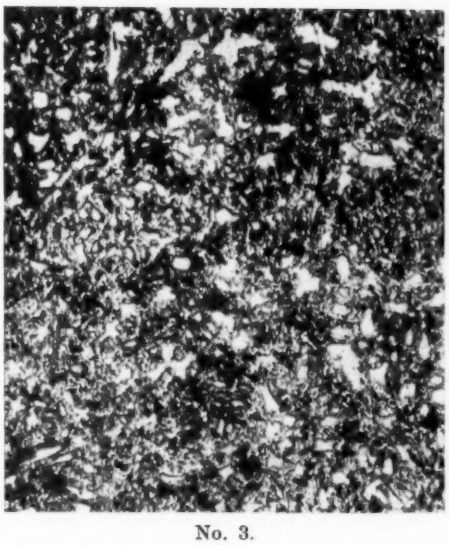
Such structural weakness cannot be eliminated by heat-treatment, and if used for forgings or pressings will always carry the defects of the casting.



No. 1.



No. 2.



No. 3.

FIG. 11.—ILLUSTRATING THE MICROSTRUCTURE OF TWO EXTREMES, MAG. 50 DIAS.

Its prevention necessitates the establishment of such conditions as will ensure crystallisation from independent centres from within (Fig. 9). There are three methods which render this possible:—(1) Control of pouring temperature and running slowly; (2) change the nature of the solution; (3) introduce some finely divided insoluble substance in the molten metal to create a nuclear action for the germination of the crystal grains.

To demonstrate this a high tenacity brass and an aluminium bronze will be considered, alloys which are prone to crystal weakness under the slightest influences of temperature and time.

### High Tenacity Beta Brass.

This alloy, which contains Cu, 59; Zn, 38; and Al, 3 per cent., was chosen because of its simple polygonal structure and tendency to develop large coarse crystal grains under the slightest influence of purity, temperature and time, as shown in Fig. 1. Pure metals were used in manufacture. The temperature and rate of pouring were adjusted so that only equiaxed crystal grains would be formed. The rate of cooling was maintained constant by casting in the ordinary 3-in. sq. ingot mould controlling its temperature at 110 deg. F. for casting.

The number of crystal grains obtained when made in this way was 152 per sq. cm. Details of the physical test results obtained are embodied in Table I. After forging the lower half of the ingot in one heating into a 1-in. sq. bar, the number of crystal grains was increased to 2,535 per sq. cm., which reduction in dimension is shown to be responsible for an all-round improvement in strength, ductility and shock-resisting properties.

Iron alloyed with copper gives rise to a high melting-point constituent containing approximately 8.0 per cent. copper of a density slightly less than that of brass. The suspension of this compound in molten brass in a finely divided state and homogeneously distributed presents no difficulties in quantities of up to 1.0 per cent. iron.

The test results of alloy 1A show the effect of 1.0 per cent. iron on alloy No. 1 in both the cast and forged conditions, the iron being substituted for a similar quantity of zinc. The effect has been to yield a casting of physical properties equal almost to those obtained from alloy No. 1 after forging; whilst, it will be observed, the number of crystal grains has been raised from 152 per sq. cm. to 2,500 per sq. cm. A further interesting feature of this alloy is that it is little improved by mechanical work and heat treatment.

### Aluminium Bronze.

Alloy No. 2, Table I, portrays the test results obtained from this alloy—which possesses a duplex structure—when made under controlled conditions. It presents very similar features to alloy 1A, although the result was obtained in quite a different way.

### Class II Alloys.

As the range of freezing temperature increases the more susceptible do alloys become to the influence of temperature and time. In consequence of this, castings are more prone to columnar crystallisation, weak-crystal zones, sponginess, and general unsoundness than alloys of Class I.

Of the well-known alloys representative of the above alpha brass, tin bronzes, cast iron and alloy steel will be considered.

### Alpha Brass.

The special features of castings made in this material being the ornamental appearance, resistance to corrosion and ductility, structural weakness resulting from differential freezing is only of secondary importance. That it can be demonstrated to exert a pronounced influence on the properties of a material whose constituents have a high alloying power and which freezes through so short a range of temperature is, however, of the highest importance in the manufacture of brass castings as a whole.

The micro-structure of this simple phase alloy when cast from a normal temperature into a 1-in. slab is illustrated by photomicrograph 1, Fig. 10, depicting the cored or heterogeneous crystal structure obtained. After cold-rolling and annealing the slab, this coarse structure and heterogeneity are removed and replaced by a simple homogeneous structure consisting of polygonal twin grains, as shown in photomicrograph No. 4, Fig. 10.

XUM

The test results and details of treatment given both before and after removal of the cast structure are embodied in Table II, alloy No. 1. These show refining of the grain to have resulted in raising the yield point 1.5 tons, the tensile strength 4.8 tons, the elongation 10, and the reduction of area 13.8 points.

Representing a purity which is rarely attained in ordinary practice, the presence of impurities must be either to accentuate or eliminate casting structural weakness. The effect of soluble impurities which extend the freezing range and intensify differential freezing will necessitate a more rigid adjustment of both the temperature and time factors, whilst insoluble impurities if distributed homogenously, and do not give rise to mechanical weakness, must automatically reduce the dimension of the crystal grain and crystal heterogeneity. The presence of such impurities would, therefore, not only result in the production of stronger and tougher castings, but render possible a wider latitude of both temperature and time.

To demonstrate the effect of impurities two casts were made alongside with the pure alloy; to the one 1 per cent. of arsenic was added, and to the other 1 per cent. of iron. Because arsenic is soluble in molten brass and forms an arsenide of zinc and copper, its influence on brass should be somewhat similar to that of phosphorus in iron or steel, *i.e.*, to increase heterogeneity due to the extended freezing range, and to embrittle, due to the deposition of the low melting-point and brittle constituent at the junction of adjacent crystal grains. Alloy No. 2 (Table II) gives the test results obtained as cast, and after the same treatment—cold rolling and annealing—as given to alloy No. 1. As cast, the properties are much impaired, both the strength and ductility being appreciably reduced. After the attempt to remove the cast structure, the properties are much improved, but still inferior to those of the pure material. Photomicrograph 2 (Fig. 10) illustrates the microstructure as cast. The effect of arsenic is shown to intensify the cored structure of ordinary 70:30 brass, and to have resulted in the deposition of a low-melting point brittle constituent at the junction of the crystal grains as anticipated, and which is responsible for the poor test results obtained.

Iron, from the experience with alloy 1, Table I of Class I, should exert a beneficial influence in the same way, and the iron-rich constituent should be deposited in the centre rather than at the junction of the crystal grain, strengthening without embrittling.

Alloy No. 3 (Table II) shows the test results obtained. The outstanding feature here is that the casting possesses a strength and shock-resisting power superior to and equal in ductility and malleability to pure 70:30 brass after its cast structure has been removed by means of mechanical work and heat-treatment.

The explanation of this is clear from photomicrograph No. 3 (Fig. 10). The effect of the iron has been to reduce the crystal grain to such an extent that, despite the freezing range of the alloy, it does not display any heterogeneity. It will be observed also that the alloy, in contradis-

TABLE I.—*The Mechanical Properties of Aluminium Beta Brass.*

| Mark. | Composition. | | | | Physical condition. | Number of Crystals per sq. C/M. | Y.P. tons per sq. in. | M.S. tons per sq. in. | E. % on 2 in. | R.A. % | Brinell hardness No. | Alternating Impact No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cu. | Zn. | AL. | Fe. | | | | | | | | |
| 1. | 59 | 38 | 3 | — | Cast .. | 152 | 20.5 | 38.6 | 19.0 | 21.5 | 159 | 23 |
| | | | | | Forged | 2,535 | 18.9 | 43.0 | 29.0 | 33.5 | 159 | 27 |
| 1A. | 59 | 37 | 3 | 1 | Cast .. | 2,500 | 18.6 | 44.5 | 26.0 | 27.0 | 159 | 19 |
| | | | | | Forged | 2,565 | 19.8 | 44.9 | 27.0 | 29.0 | 159 | 26 |
| | Cu. | AL. | Mn. | Fe. | | | | | | | | |
| 2. | 89.59 | 9.36 | 0.90 | 0.10 | Cast .. | — | 11.7 | 29.9 | 43.0 | 39.2 | 97 | 19 |
| | | | | | Forged | — | 11.5 | 30.6 | 45.0 | 45.0 | 101 | 20 |

TABLE II.—*The Mechanical Properties of Alpha Brass.*

| Mark. | Composition. | | | | Physical state and Treatment. | Y.P. tons per sq. in. | M.S. tons per sq. in. | E. % | R.A. % | Brinell hardness No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cu. | Zn. | As. | Fe. | | | | | | |
| 1 | 70 | 30 | — | Tr. | Cast .. .. .. | 6.50 | 16.70 | 58.0 | 48.2 | 55 |
| | | | | | Cold worked and annealed .. .. | 8.00 | 21.50 | 68.00 | 62.0 | 55 |
| 2 | 69.16 | 29.87 | 0.97 | Tr. | Cast .. .. .. | 5.8 | 13.20 | 23.0 | 21.5 | 52 |
| | | | | | Cold worked and annealed .. .. | 8.0 | 19.20 | 38.0 | 19.1 | 59 |
| 3 | 69.5 | 29.5 | Nil | 1.0 | Cast .. .. .. | 10.70 | 24.00 | 50.00 | 59.30 | 72 |
| | | | | | Cold worked and annealed .. .. | 11.00 | 26.50 | 54.00 | 67.00 | 76 |

TABLE III.—*The Influence of varying Casting Temperatures on the Properties of Phosphor-Bronze Castings.*

| Cast No. | Composition. | | | Casting-temperature in deg. C. | Y.P. tons per sq. in. | M.S. tons per sq. in. | E. % on 2 in. | R.A. % | Fracture. | Brinell hardness No. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cu. | Sn. | P. | | | | | | | |
| 1 | 93.90 | 5.25 | 0.85 | 1,112 | 10.40 | 23.50 | 23.50 | 4.50 | Earthy, dendritic, exhibiting slight oxide inclusions. | 73 |
| 2 | — | — | — | 1,085 | 10.90 | 24.60 | 28.00 | 6.20 | As Cast No. 1, but free from defects. | 75 |
| 3 | — | — | — | 1,075 | 10.90 | 25.30 | 30.00 | 6.60 | Fine, earthy, almost free from crystallinity. | 78 |
| 4 | — | — | — | 1,050 | 10.40 | 24.20 | 22.50 | 5.00 | Earthy, with a small copper - coloured cavity in the centre. | 78 |
| 5 | — | — | — | 1,044 | 10.00 | 20.40 | 12.50 | 3.10 | As Cast No. 4, but more defective. | 74 |
| 6 | — | — | — | 1,040 | 10.00 | 18.80 | 8.00 | 2.70 | Earthy, exhibiting copper - coloured patches in which cavities are contained. | 79 |

tinction to alloy No. 2 shows the least improvement by mechanical work and heat-treatment. In many ways the test results are very similar, whereas the improvement effected by the elimination of the cast structure is most marked with the arsenical brass.

### Tin Bronzes.

These alloys have a protracted range of solidification, and are somewhat analogous to ordinary grey cast iron, being peculiarly susceptible to the influence of both temperature and time.

From the range of alloys this series offers, the two commoner have been selected for consideration, viz., phosphor-bronze and Admiralty gun-metal.

Table III shows the physical test results obtained from phosphor-bronze when poured at various temperatures between 1,112 deg. C. and 1,040 deg. C. into chill bars 9 in. × 1¼ in. × 1¼ in. Photomicrographs 1, 2 and 3 (Fig. 11) illustrate the microstructure of two extremes, and the bar cast at an intermediate temperature, at a magnification of 50 times. No. 1 shows the well-developed dendritic structure and the heterogeneity resulting from differential freezing despite the rate of cooling. No. 2 portrays a finer structure and a complete absence of the well-developed dendrites of No. 1. No. 3 presents an adumbrant cellular structure together with mechanical defects due to pouring too cold.

These microstructures are self-explanatory of the test results obtained, and show that a dendritic structure resulting from high casting temperature reduces both the strength and ductility, and that casting cold is equally injurious owing to the formation of defects due to entrapped oxide, overlaps and blowholes.

### Admiralty Gun-Metal.

Freezing through a more extended range—approximately 200 deg. C.—the difficulty of casting solid and free from crystal weakness increases proportionately.

Photomicrograph 1 (Fig. 12) shows the microstructure obtained from this alloy when cast in a chill mould. This large crystal structure, obtained by rapid cooling, serves to indicate the difficulties which will be encountered in the manufacture of sound sand castings, and that to attempt production without a knowledge of the influence of both temperature and time is courting trouble and losses.

Consider, as a practical example, the simple cylindrical propeller-shaft liner casting, which is free from any complications of design. The dimensions of these reach 24 in. dia., 25 ft. long, and with a section of 1½ in. When cast in dry sand or loam moulds in the ordinary way, trouble invariably arises in the form of patches of open-texture, liquation-holes and segregation due to selective crystallisation, no matter what precautions are taken in the control of the mixture, melting and pouring temperatures or rate of running (Fig. 13).

The crystallisation range is so extended that solidity and homogeneity are not affected materially by small quantities of either soluble or insoluble impurities. Soluble impurities such as aluminium, antimony and arsenic have but little deleterious effect. Pb, a low melting-point metal, which is often introduced in considerable quantities and which does not alloy with copper, increases casting difficulties. To a certain extent its injurious influence in this direction may be overcome by the introduction of antimony or sulphur, which combines with both copper and lead, and ensures the formation of an alloy with these constituents. Sulphur is best introduced by means of galena.

On the other hand, metals such as iron, chromium and titanium, which give rise to the formation of insoluble compounds, are not of the same value as in brass, for example, whilst any beneficial influence that they may have as "grain-refiners" is often negatived by their tendency to give rise to hard spots and to segregate.

The manufacture of sound castings thus resolves itself into the question of the time taken to solidify, although temperature and rate of running are factors which cannot be ignored altogether. The methods suggesting themselves, therefore, for the manufacture of sound propeller-shaft liners were (1) cast centrifugally; (2) build the mould up by means of a series of cast-iron rings; (3) insert chills into the sand, cool the sand by air or water pipes, or allow both mould and core to cool to room temperature 80 deg. F., for castings.

Method No. 1 proved most successful, but demands special plant. The use of chills increases cost. Cooling the mould by means of air and water pipes proved successful but somewhat

TABLE IV.—*Effect of Forging on the Physical Properties of Nickel Chrome Steel (Composition C 0.50, Si 0.10, Mn 0.071, P 0.03 S 0.025, Ni 2.00, and Cr 2.01 per cent.) in the Annealed and Hardened Condition.*

| Mark. | Physical condition. | Treatment. | Y.P. tons per sq. in. | M.S. tons per sq. in. | E. % on 2 in. | R.A. % | Fracture. | Brinell hardness No. | Calculated tenacity. | Alternating impact No. | Izod impact, ft.-lbs. absorbed. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | "As Cast" | None | 28.80 | 30.50 | 1.50 | 1.00 | Coarse crystalline, exhibiting brilliant crystal facets. | 223 | 55 | 1 | 4 |
| 1. | "As Cast" | Annealed 900°C. 1 hour cooled in furnace. Reannealed 790°C. 1 hour, cooled in furnace. | 31.50 | 50.00 | 13.50 | 28.00 | Coarse Crystalline, but of dark velvety appearance. | 207 | 51 | 107 | 26 |
| | "As Cast" | Annealed as above and oil-hardened. | 54.20 | 54.20 | Nil. | Nil. | Fine, amorphous exhibiting an adumbrant dendritic pattern. | 578 | 140 | 1 | 1½ |
| | "As Forged" reduced to half the original cross sectional area. | Annealed 900°C 1 hr. Cooled in furnace. Reannealed 790°C. 1 hr. Cooled in furnace. | 31.80 | 50.00 | 23.00 | 55.00 | Grey velvety. Cup and Cone. | 207 | 51 | 173 | 53 |
| 1F. | "As Forged" reduced to half the original cross sectional area. | Annealed as above and oil-hardened. | 80.00 | 80.00 | 0.30 | Nil. | Fine, amorphous. | 578 | 140 | 5 | 3½ |
| | "As Forged" reduced to $\frac{1}{4}$th the original cross sectional area. | Annealed 900°C. 1 hr. Cooled in furnace. Reannealed 790°C. 1 hr. Cooled in furnace. | 30.00 | 49.60 | 26.00 | 63.00 | Grey, velvety. Cup and Cone. | 207 | 51 | 201 | 72 |
| 1 FF. | "As Forged", reduced to $\frac{1}{4}$th the original cross sectional area. | Annealed as above and oil-hardened. | 124.00 | 124.00 | 1.00 | Nil. | Fine, amorphous. | 578 | 140 | 7 | 2½ |

dangerous, and the experiments were discontinued when it was found that these castings could be produced successfully in a simple sand mould by making conditions as favourable as possible for rapid cooling, by controlling the casting temperature between 1,050 and 1,100 deg. C., and running quickly from the top.

This example, chosen to illustrate the difficulties encountered with this metal and the rigid control necessary in the manufacture of sound castings of

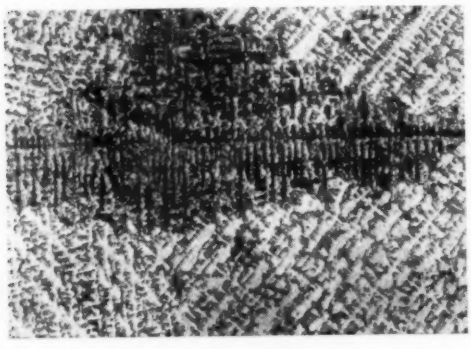


FIG. 12.—SHOWS MICROSTRUCTURE OF GUN-METAL CAST IN A CHILL MOULD, MAG. 50 DIAS.

simple section, also shows the relative importance of design in limiting and proportioning of sections in bronze castings of complex form.

### Grey Cast Iron.

Columnar crystallisation and weak crystal zones common to metals and alloys when cast hot and rapidly cooled are rarely encountered in grey cast iron cast under similar conditions. Die casting with a high-carbon hematite iron, free from weak crystal zones—and which machines, without annealing—is quite commonplace, despite a freezing range of 200 deg. C. Modify the composition, however, such that all the carbon is retained in complete solution at normal temperatures of melting and pouring, and it behaves as any other alloy, and strength becomes a fruition of temperature of pouring and rate of cooling.

In ordinary cupola practice the change between these two extremes is gradual, and not subject entirely to chemical control. It is for this reason that grey iron has so long been regarded as an uncertain metallurgical product.

Speaking broadly, casting temperature influences are not pronounced on ordinary sand castings, although general experience indicates that the higher the casting temperature, the closer and finer the grain; although published test figures are confusing, West and Longmuir finding the best results could be obtained from a low or medium temperature, whilst Cook and others state casting hot gives the best test results.

Does not this anomalous behaviour of grey cast iron suggest that it only differs from true alloys by the presence of suspended graphite particles in the molten iron, and that the explanation of the conflicting test results published by various investigators must be sought in the nuclear action of free graphite on the crystal growth during solidjfication. From this theory it is not difficult to understand that an iron containing but little free graphite will be peculiarly susceptible to casting temperature influences, a high temperature being responsible for a weak crystal formation; whilst an iron which contains appreciable quantities of suspended graphite would be immune from such crystal weakness. Similarly, does it not explain why the latter iron is soft and weak when poured cold?

Regarded in this way, grey cast iron falls into line with true alloys, and its metallurgy is simplified.

### Steel.

The high temperature necessary in melting and the ready oxidation of iron and its alloys render the manufacture of sound steel castings peculiarly difficult, and although science now furnishes an explanation of the different forces operating in manufacture, remedial measures are inter-dependent upon plant limitations and common sense.

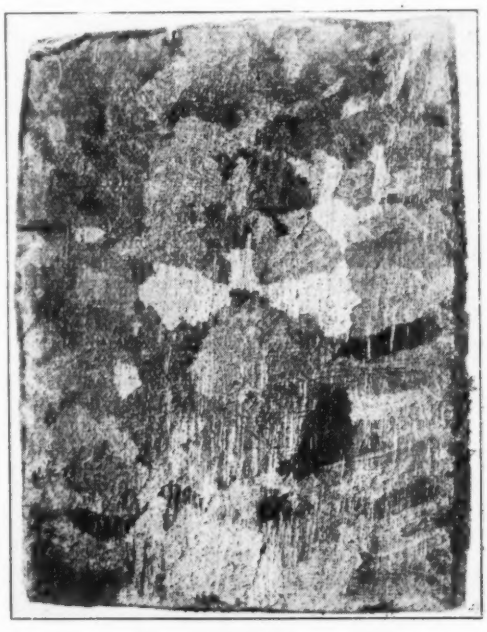
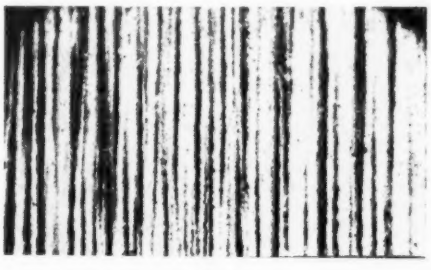


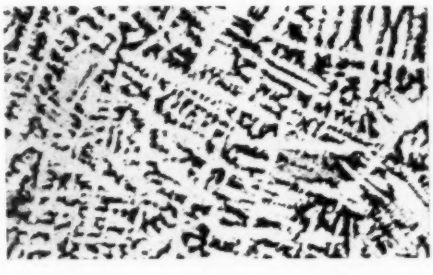
FIG. 13.—SHOWING PATCHES OF OPEN TEXTURE, LIQUATION HOLES AND SEGREGATION IN A PROPELLER-SHAFT LINER CASTING, MAG. 5 DIAS.

A noteworthy feature of the alloys already considered is that the harder they become the more susceptible are they to crystal weakness. Cast steel is no exception, and the ill-effects of a defective primary crystal formation manifests itself throughout the career of the casting, no matter the subsequent treatment. Photomicrographs Nos. 1, 2 and 3 (Fig. 14) delineate the persistency of such structural weakness in a nickel-chrome steel which was scorched in melting and poured too hot. No. 1 is as cast, No. 2 after forging to half the original cross-sectional area, No. 3 after forging to one-eleventh the original in area in three heatings. They show heat-treatment and mechanical work to have merely crushed the primary dendrites together without removing cleavage brittleness.

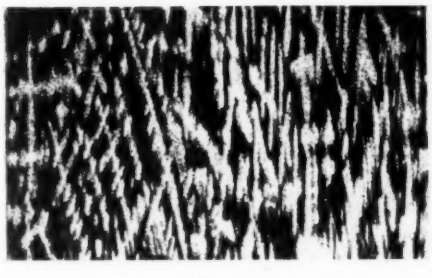
The test results obtained at each stage of manufacture, as cast; as cast and annealed; and as cast and heat-treated to refine the structure of the carbide, also after the same heat-treatment in the forged conditions, are detailed in Table IV.



No. 1.



No. 2.



No. 3.

FIG. 14.—SHOWING PERSISTENCY OF STRUCTURAL WEAKNESS IN NICKEL-CHROME STEEL.

The following observations are of interest:—

The strength of the casting is 19.5 tons lower than that obtained from the forging, although of similar Brinell tenacity hardness, and is devoid of ductility. Annealing improves the ductility, although it is not comparable with that obtained from the forging. When hardened to 140 tons Brinell tenacity only 54.2 tons are actually obtained, against 80 tons tensile from the forging whose sectional area was reduced to one-half that of the casting, and 124 tons from the section reduced to one-eleventh the original cross-sectional area.

To some degree all commercial steels exhibit structural weakness, depending upon the extent of control in melting and of the pouring temperature.

### Impurities.

In view of changes which steels undergo in the process of solidification, impurities influence the mechanical properties to a degree depending upon their nature and quality. They may be classified as follows:—(1) Those insoluble in the molten metal; (2) those separating out as definite constituents during solidification; and (3) those entering into solid solution. Insoluble impurities, comprising alumina, sulphides and silicates, create a crystal growth from within and are entrapped in the meshes of the branches of the primary crystallites, thus taking a skeleton outline of the dendrite. The pressure of impurities which separate from the solution during solidification depends upon the condition of the metal as received into the ladle. If scorched or oxygenated, it is quite conceivable that oxides and gases may be rejected on freezing and appear in the finished casting in mechanical admixture at the junctions of adjacent crystal grains. An example of this type is illustrated by photomicrograph, Fig. 15. There is every reason to believe, therefore, that a correctly deoxidised steel may still contain considerable oxygen in solution, and that its solubility is increased by the presence of such refractory metals as nickel, chromium and molybdenum, which metals, incidentally, are a common source of structural weakness because of their low alloying power.

Whilst it has not been possible to consider steel to the length it deserves, it is evident that it presents much the same difficulties in regard to structural weakness as the lower melting-point alloys which freeze through a range of temperatures; that the cause and elimination presents a similar problem, and that impurities behave in the same way.

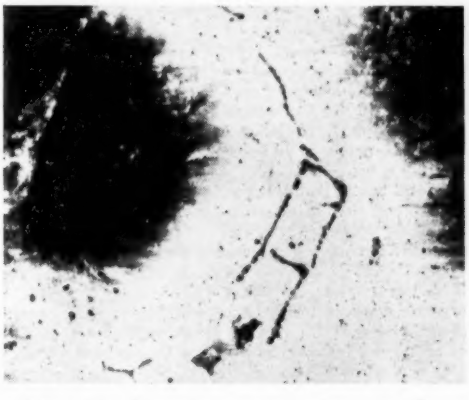


FIG. 15.—SHOWING THE PRESENCE OF IMPURITIES AT CRYSTAL BOUNDARIES.

### Conclusions.

Summarised, this Paper shows:—

(1) That analogies exist between alloys with regard to the origin, constitution and effect of the primary crystal structure on the mechanical properties of castings.

(2) That soluble impurities give rise to a structural heterogeneity in all alloys which is peculiarly persistent and detrimental to the physical properties despite subsequent treatment.

(3) The possibilities of considering grey cast iron as a true alloy.

(4) Lastly, the value of research on crystal structure in the manufacture of castings to compete with forgings and stampings.

## Institute of British Foundrymen: Propaganda Meeting in Cardiff.

Through the efforts of Mr. J. J. McClelland, a member of the London Branch of the Institute of British Foundrymen, now living at "Druslyn," Bishops Rood, Whitchurch, Glam., a meeting will be held at 6 p.m. on Saturday, January 26, at the South Wales Institute of Engineers, Park Place, Cardiff, having for its object the formation of a South Wales Branch. The Lord Mayor of Cardiff is to be present, and he will be supported by Mr. O. Stubbs, the President of the Institute. Mr. McClelland is to give a short lecture on "Shrinkage and Warping." Any member of the Institute that can take part should do so, and all local foundrymen are invited to be present or represented.

# Admiralty Gunmetal.*

By S. G. Homfray and F. Adam.

## INTRODUCTION.

It is perhaps unnecessary to specify exactly what is meant by "Admiralty Gunmetal," although it must be admitted that in spite of the strenuous efforts of the Institute of Metals, non-ferrous nomenclature is still in a deplorable state of confusion; in point of fact, this is one of the few names which is, in Great Britain, at any rate, recognised as specifying one mixture and one only, namely, an alloy consisting of 88 copper, 10 tin, and 2 per cent. spelter. It is not, however, the easiest class of gunmetal to cast.

## MATERIALS.

The choice of materials to be used falls in four classes:—(1) Virgin metals, (2) scrap, (3) ingot, and (4) turnings and borings.

In the case of some specifications the use of virgin metal only is insisted on, but it is not intended to limit it to this in this Paper. Each foundry has probably its own ideas on the best materials to use, always bearing in mind the question of cost. The authors naturally incline towards virgin metal, and there is no doubt that this is best, but in view of the greatly increased cost of such castings over those made from other materials, the judicious use of other grades must be introduced where permitted.

### Copper.

Some care is necessary in the selection of virgin metals. For instance the most commonly used is copper, that known as "best selected." This term does not, in effect, guarantee anything, but provided a brand is chosen which is registered on the London Metal Exchange, no trouble need be anticipated. Impurities to be definitely avoided are bismuth and antimony, but these are not found in reliable brands. Other impurities found are lead, iron, nickel and arsenic, but the quantity present is usually so small as to be negligible.

Tough copper contains up to 0.6 per cent. of arsenic, and if used alone will lower the strength of the material. It is, therefore, best avoided except that it may be used to the extent of showing not more than 0.2 per cent. of arsenic in the analysis of the gunmetal.

Selected copper scrap may be used, particularly clean electric wire of reasonable gauge, free from covering. Locomotive firebox plates and stays suffer in a slightly lesser extent from the same disadvantage as tough copper, and the same remarks apply. In other respects they are very suitable material, being somewhat cheaper than ingot copper, and are generally clean and reliable.

An impurity in copper not mentioned above is oxygen. This is always present in smelted coppers to a greater or lesser extent. It is sufficient, however, to state that the metal is satisfactory in this respect if the top of the ingot is flat, without a centre depression or ridge.

### Tin.

Turning to tin, here, again, brands specified as good delivery on the London Metal Exchange may be generally relied on. The largest impurity is usually lead, but provided the quantity present does not exceed 0.5 per cent. it will be quite suitable for the highest class of work. In some common brands antimony is found up to 0.5 per cent., but any of these should be strictly avoided for gunmetal work.

### Spelter.

As regards spelter, the percentage used is so small that the impurities found are of minor importance; they are principally lead, iron and cadmium. In America the various qualities of spelter have been graded into four classes; for ordinary purposes Grade "D" or "Prime Western," containing as maxima 1.5 per cent. lead, and 0.08 per cent. iron, will be quite satisfactory, or, if it is desired to be more particular, Grade "C" or "Brass Special," containing as a maximum 1.2 per cent. impurities, should be used.

### Scrap.

In regard to scrap, since the war there has been a very large quantity of Admiralty gunmetal scrap placed on the market owing to the breaking up of so many warships. Unfortunately, the average shipbreaker knows nothing about brass, and as this quality of scrap commands the highest price of any, it follows that lower grades of metal are sometimes found in consignments described as Admiralty metal. With care, and periodical analysis of the shop mixture, this scrap may be used for ordinary work, and being usually clean, heavy material no further difficulties should arise.

Many firms sell ingot metal guaranteed Admiralty quality, and these are generally of reliable analysis. They are derived from melting up large quantities of turnings and borings in reverberatory furnaces. Ingot metal possesses the advantage of more reliable analysis over scrap, but the latter is usually cleaner, owing to the ingots being derived from borings. Turnings and borings, if they are to be used direct, must necessarily be very carefully selected, and should be magnetised before use.

For many purposes there is no objection to using a percentage, but the difficulty is to obtain them free from other mixtures.

## MIXTURES.

The authors are not aware of the origin of Admiralty gunmetal; copper 90, tin 10 per cent. is an alloy that was frequently used certainly by the Romans, and probably at considerably earlier times. It is thought that the zinc has been added at a comparatively recent date to act as a deoxidiser and improve the casting properties. The alloy derives its name from its use in naval ordnance, where, up to the introduction of manganese bronze, it was universally used, and its use there is still extensive. In addition, it is generally admitted as the most suitable alloy for engine parts and steam fittings. At the same time it must be confessed that it is not an ideal alloy in which to make castings, particularly if they are of heavy section. The drawback is the long range of solidification. This, of course, is common to all copper-tin alloys, but the range between initial and final solidification in Admiralty metal amounts to about 200 deg. C., and is at its maximum in this alloy. This causes the defect known as "separation," and any thick section of this metal cooled normally will show this to some degree. It can be readily identified, as the centre of the section will be appreciably whiter in colour than the outside, due to the fact that the portion of the alloy to solidify last, which is naturally in the centre, is considerably higher in tin than the outside. This latter assertion can be readily proved by analysing the outer layer and the centre.

There is a prevailing idea that the mixture put up strictly to the quantities 88:10:2 will not give the best results, both in casting and on tensile testing there does appear to be some reason for this idea from the previous remarks, but the permissible departure from the quantities brings no appreciable relief, and from personal experiments the authors cannot distinguish any inferiority when tested in tensile in the standard mixture to those near it.

## FURNACES.

There is to-day a large variety of types of furnaces suitable for melting gunmetal, most of which possess advantages of their own. The old-fashioned pit-fire still holds its own, and has been improved in details of design in recent years. It is a necessity in every foundry, especially for melting 100 to 200 lb charges. It is cheap to instal and costs little in upkeep. The more recent coke-fired, forced-draught tilting furnace is useful for melting 400 to 600 lbs. charges. In this furnace the crucible is not withdrawn, but the furnace is tilted and the metal poured into ladles. This leads to considerable economy in crucible cost. They are also low in coke consumption. Starting with a hot 400-lb. furnace, a charge of new metal can be

* A Paper read before the Newcastle Section of the Institute of Metals.

melted in 1½ hours, and a charge of scrap in 1¼ hours, with an average of 3 lbs. of metal melted per lb. of coke in the former case and 5 lbs. in the latter. The average life of the crucibles can be taken as 30 heats.

The authors have found that furnaces lined with carborundum fire-sand last longer, are easier to line, and are cheaper to maintain than those lined with firebricks. There is undoubtedly a prejudice against these furnaces, but personal experience is favourable to them. During the war Messrs. Armstrong Whitworth had over seventy 6-cwt. Morgan tilting furnaces in use, melting about 700 tons per week of brass, for the manufacture of cartridge cases and fuses, and manned almost entirely by initially unskilled labour.

### Reverberatory Furnaces show Advantages for Large Quantities.

For melting large charges of gunmetal, the reverberatory coal-fired furnace possesses distinct advantages. Although slower in time of melting and not so economical in fuel, there is a very considerable saving of time and labour in tapping several tons into a ladle as compared to emptying a large number of crucible furnaces. In addition, the metal is all at one temperature and can be ready for casting at a high temperature if required. Scrap is more easily dealt with in these furnaces, as larger pieces can be charged in than into crucibles. The melting of turnings and borings in these furnaces is widely practised, and need not be discussed here.

### Electric Melting.

It is not thought there is an electric furnace in operation on the North-East Coast, and there is not the same attraction here as in countries where coke is poor and expensive and electric power cheap. The development of this furnace received a great impetus in America during the war, owing to the difficulty of obtaining suitable material for making crucibles. They are distinctly attractive, as the temperature may be accurately and easily controlled, there are no objectionable coke fumes and no ashes and no clinker to remove. The only data available refer to the melting of 60/40 brass, and G. H. Clamer, in his Paper, "The Induction Electrical Furnace," states that about 10 lbs. of brass can be melted per unit of electricity, which, with electricity at ¾d. per unit, gives a fuel cost of 14s. per ton. As coke, even in this district, costs 44s. per ton, it will be seen that the fuel cost per ton for electric melting is within a few shillings more than for coke, which is more than balanced by the other advantages. Unfortunately, the first cost of these furnaces is very high.

## MELTING PRACTICE.

This will only be considered from the standpoint of crucible melting, as being the most generally used and possessing the best heat control and facilities for mixing.

In melting the alloy from virgin metals, too much care cannot be paid to preventing overheating and oxidation of the copper. Overheating requires care, while for oxidation nothing is better than a covering of lump charcoal. As soon as the copper is melted, the zinc should be added, and the mixture well stirred. In a few minutes the tin is added and the mixture again well stirred. By adding the zinc before the tin, the former fulfils its true function of deoxidising the copper, whereas if the process is reversed some tin is apt to be lost by oxidation.

If the alloy is required in ingot form, it should be poured into the moulds as soon as possible after the tin has been added. If castings are to be made it is only necessary to bring the mixture to the desired temperature and then cast. It is generally agreed that a more perfectly alloyed metal is obtained on the second melting. In these days of keen competition this must be looked upon more as a luxury than a necessity, although the authors would still recommend it for hydraulic gunmetal (12 to 13 per cent. tin). The question can be overcome in quite a satisfactory way by always using a proportion of heads and gates, say one-third. If all scrap is being melted we would still recommend charcoal as a covering.

### Influence of Repeated Re-Melting.

The question of injury to gunmetal through repeated re-melting has been often discussed, and usually dismissed in the following words: "It is usually considered injurious to the metal to re-melt repeatedly." As the authors have been brought up in an atmosphere of tensile tests, they are inclined to measure the suitability of any lot of metal by its tensile test, and they believe that this will be accepted as a ready method. In order, therefore, to test this question of repeated re-melts the following experiments were carried out:—A 150-lbs. charge of new metal was melted in a coke-fired natural draught pit-furnace, and after raising it to the required temperature a standard size test-piece was cast into green-sand; the remainder of the alloy was then ingotted. The ingots and gates from the test-piece were then re-melted, and this was repeated five times, on each occasion a test-piece being cast, so that the same alloy was actually melted six times without any new material of any sort being added. The pyrometer was used for each cast, and all the pieces were cast at the same temperature. The results of the tensile tests are shown in Table 1.

TABLE I.—*Influence of Re-melting Gunmetal on the Tensile Strength.*

| No. of cast. | Y.P. tons per sq. in. | M.S. tons per sq. in. | Elongation % on 2 ins. |
|---|---|---|---|
| 1st .. | 8.5 | 17.2 | 25.0 |
| 2nd .. | 9 0 | 17.2 | 21.5 |
| 3rd .. | 9.8 | 16.4 | 19.0 |
| 4th .. | 9,0 | 16.8 | 20.0 |
| 5th .. | 8.5 | 15.2 | 14.5* |
| 6th .. | 8.8 | 16.2 | 18 5 |

* Broke outside pops.

Drillings were taken from the first and last pieces, and the analysis of these were:—

| | Cu. | Sn. | Zn. | Pb. | Fe. |
|---|---|---|---|---|---|
| 1st test .. | 87.65 | 10.26 | 1.99 | 0.10 | Trace |
| 6th test .. | 87.93 | 10.26 | 1.70 | 0.11 | Trace |

These results are somewhat remarkable; the yield point has not altered, the break has fallen one ton, but it is still above the Admiralty requirements of 16 tons, and the elongation, although lower, is well above the 8 per cent. demanded. Turning to the analysis, it will be noticed that the sole alteration has been a loss of 0.3 per cent. in the zinc content—that is to say, that in six meltings 15 per cent. of the zinc content has been lost. In mixing the alloy for the first test the tin was added to the molten copper, and then the zinc, the reason being that this is the method more generally followed, and therefore was more likely to represent general practice.

## MOULDING SAND.

No special quality of moulding sand is required for this particular alloy. The principal moulding sands used in brass founding in England are Erith, Mansfield, Belfast, Bimingham and Falkirk. The chief, and also the important, constituents of moulding sand are silica and alumina, the impurities consisting of lime, magnesia and ferric oxide; water must also be present to give the necessary bonding effect to the components. Silica is the refractory element, and alumina or clay supplies the cohesiveness.

Of the sands cited, Erith is probably the cheapest to obtain in the north-eastern district, and is quite satisfactory. It possesses the necessary bonding and refractory qualities, and it produces a particularly clean skin on gunmetal castings.

## MOULDING AND CASTING.

Undoubtedly insufficient consideration is given by the designer and draughtsmen to the foundry. It must be confessed that in the foundry, particularly in the mould during casting, and even more after casting and during solidification, factors are operating, irrespective of all care that can be taken or forethought exercised, that are beyond human control. The authors have on many occasions encountered difficult moulding problems which, with slight alterations to the design, would have been made much simpler jobs for the foundry. Allied to the difficulties of producing sound castings is increased cost of production, as these two are bound to operate together. Apart from these

points, which the draughtsman may consider as purely selfish, excessive thickness of metal, sudden change of section, sharp corners and such like, decrease the effective strength of the casting, and perhaps, therefore, the efficiency of the whole apparatus. It appears to be generally imagined that because a test-piece cast on to an article will give a tensile test of 16 tons, all parts of the casting will be as strong as this. This is a delusion. Some parts will be stronger and some weaker; depending on the design and taking 16 tons as the test-piece strength, it is probable that under certain conditions figures ranging from 10 tons to 20 tons would be obtained from different parts of a casting.

### Gating.

One of the most important factors a moulder has to consider on every new job he undertakes is the gating, as it must be remembered that however carefully the mould may have been made, cored up and vented, if not correctly gated, good sound castings cannot result. The points to be considered are position of gate on casting, section of gate, and height and diameter of riser. There is in every individual casting a correct place from which to gate it. In some difficult types of castings it can be conceded that this can only be found by actual experiment, but in general this is not so, and, generally speaking, the two most important points are gating from the heaviest part of the casting or from the lowest part of the mould, and if these two are the same, so much the better, but, of course, no fixed rule can be laid down. Section or size of gate is of great importance, as it must be remembered that the gate has two separate functions to perform, for in addition to running the casting it has also to feed it, in which it is assisted by the pressure due to the height of the riser, while fluid. It is questionable whether the moulder really understands fully the point that it is the pressure due to the height of the riser while fluid that is going to give him a dense, and consequently sound casting, and not the diameter of the riser. This, of course, is an elementary law of hydrostatics. Professor Turner, in his Paper on "The Casting of Metals," read before the Institute of Metals in May, 1921,* puts the matter very clearly by stating: "Perhaps the best-known device to ensure 'dense metal' is the provision of a casting head of sufficient height and thickness. As there is an idea that the density of metal is increased by the pressure of such a head, a few words on this subject may not be out of place. Let it be assumed, for example, that the height of head of metal is 2 ft. Now, a height of 2 ft. of water will give a pressure of about 1 lb. per sq. in., and 2 ft. of brass or iron about 7 lbs. Now, suppose a large casting has a surface of 5 ft. square in a horizontal plane, this would give 60 × 60, or 3,600 sq. in., and with fluid brass or cast iron the hydrostatic upward pressure would amount to seven times 3,600 lbs., or, say 11 tons. The total hydrostatic pressure would therefore be considerable, and unless the upper box were well weighted it would lift and the casting be spoiled."

It will be seen from these remarks that it is clearly height only of riser and not diameter that governs the fluid pressure in the mould. The function of the diameter in the riser is to provide a reservoir from which the casting can be fed through the gate while solidifying. The gate must be of sufficient section to remain fluid sufficiently long to feed the casting, otherwise there is a liability for the casting to be drawn at the gate, but on the other hand, if the section is too large, the casting may be called on to feed the gate, and the same defect will appear.

As to the form of the gate, a heel to every gate wherever possible is strongly advocated, as the first flow of metal down the riser is liable to break and form dross. The heel acts as a receptacle for the dross, and tends to prevent it from entering the mould. This refers to the ordinary form of horizontal gate from a vertical riser. For other forms, a worm gate would only be used where the casting is of such construction that an ordinary gate is not suitable. The drop gate, *i.e.*, dropping the metal directly into a portion of the casting, has not been found successful. In some castings it may be necessary to provide a flow or flows to feed heavy parts or flanges, in which case they should preferably be "blind," so as not to lose pressure in the casting. As a dressing for moulds flour is thought to be the best for green-sand mould, while for dry-sand moulds plumbago mixed with clay-wash is preferable.

### Tensile Tests.

Where tensile tests are called for it is naturally essential that particular care and attention should be taken to produce satisfactory results, as delivery of the casting is dependent on this, and foundry costs are inflated by an excessive percentage of rejections. It is also well to aim at consistent results, as these inspire confidence in inspectors. For gunmetal (88:10:2) the Admiralty, in their most recent specifications for gun-mounting work, have increased the specification from 14 tons per sq. in. tensile with 7½ per cent. elongation to 16 tons tensile with 8 per cent. elongation. This is the most stringent specification for this metal in existence. As the composition of the material is also rigidly specified, it is only by most increased care in the manufacture that an increase in rejections can be avoided. Apart from care in melting, there are four controlling factors in getting the best results at tensile test, which are, position of test piece, height of riser, size of test piece, and pouring temperature.

Experience has shown that it is of great importance to have the test piece in such a position that there is no halt or check in the pouring of it when once commenced. This halt is liable to occur if the test piece is placed in such a position that after it has been partly filled the metal commences running into the mould itself, and until the lower parts of the mould are filled it causes what has been referred to as a halt in filling the test piece. This causes dross to collect which will not be eliminated. To overcome this it is preferable to place the test piece so that it will fill first and the casting afterwards.

In some cases this may necessitate an additional box part to enable the test piece to be placed directly under the casting, but this is worth while if it shows good results, such as one recently noticed, giving 18.8 tons tensile with 33 per cent. elongation. A test piece in such a position has the advantage of getting an uninterrupted pour with a good height of riser. If height of riser plays such an important part in producing good, sound castings, it must follow that it will help very materially in producing sound test pieces.

The authors have at various times tried different sizes and shapes, such as round, square and shaped, and after many experiments they have come to the conclusion that the best results are obtained from square test bars. For the ordinary piece of 0.564 in. diameter and 2 in. breaking length the cast bar should be 1⅛ in. square × 6 in. long.

## POURING TEMPERATURE.

Whatever care has been given to the moulding, core making and venting, if the alloy is not poured at the correct temperature success cannot be secured. Personally the authors would like to see the pyrometer used for every cast, but this cannot be done. They concede that hundreds of good castings have been made without temperature control, but at the same time there is a very great element of chance in judging temperatures, because the most experienced man will be misled by the conditions of light, from sunshine to a dull day.

Dr. Carpenter and Miss Elam, in a Paper read before the Institute of Metals in 1918, recommended that gunmetal should be cast between the temperatures of 1,115 to 1,270 deg. C.

Mr. R. T. Rolf, at the Birmingham Section of the Institute of Metals in 1921, criticising these figures, says "his own experience was that in making large castings the top limit of 1,270 deg. C. should not be exceeded. The lower limit of 1,115 deg. C. might be rated a little too high, as in his own experiments he obtained no falling off till the metal had cooled down to about 1,060 deg.

Mr. J. Arnott, in his lecture on "Gunmetal," read before the Institute of British Foundrymen at the Scottish Branch 1920, gives his experience on an alloy of 87 copper, 9 tin, 3 zinc, and 1 per

*See FOUNDRY TRADE JOURNAL, Vol. 25, Nos. 247 and 248.

cent. lead, and states that he found the best casting temperature was from 1,155 to 1,215 deg. C.

Mr. F. W. Rowe, in his Paper read before the Lancashire Branch of the Institute of British Foundrymen this year, says: "Most brass-foundrymen prefer to run their light work at about 1,188 to 1,200 deg. C., and heavy work at 1,150 to 1,170 deg. C.

In "Gunmetal and Brass Founding," by the brothers Primrose, the highest temperature they advise is 1,155 deg. C. for small work, between 1,035 and 1,070 deg. C. for medium castings having no very great difference in cross-sectional area, and for extremely heavy work with no intricate cores to negotiate, not much above 1,020 deg. C. So that, comparing the highest temperatures given by these different authorities, we have a range of from 1,020 to 1,270 deg. C.

From experience the authors are of the opinion that the range of the best casting temperature for 88:10:2 alloy is entirely between 1,075 and 1,175 deg. C., and that castings poured below the former will not be sound, and that separation will be produced in those poured above 1,175 deg. C. The authors are practically in agreement with Mr. Rolf when he refers to no falling off till the metal has cooled down to about 1,060 deg. C., but should have preferred to give the figure at 1,075 deg. C. In confirmation of the high and low limit, the result of experience is submitted, and it will be of interest to note the test results (Table II.) of six different temperature casts. The alloy used was new metal, melted in the rotation of copper, zinc and tin, and the tests were the authors' standard size, cast in green sand.

TABLE II.—*Influence of Casting Temperature on Tensile Strength.*

| Casting temp. Deg. C. | Y.P. Tons per sq. in. | M.S. Tons per sq. in. | E.% |
|---|---|---|---|
| 1175 .. | 8.5 | 17.9 | 25.5 |
| 1150 .. | 9.0 | 18.1 | 27.0 |
| 1120 .. | 9.2 | 19.0 | 29.5 |
| 1093 .. | 9.8 | 18.8 | 23.5 |
| 1065 .. | 9.8 | 17.0 | 16.5 |
| 1035 .. | 9.0 | 13.0 | 9.6 |

It will be seen that the best results are those cast at 1,120 and 1,090 deg., but it may be that those temperatures are not suitable for the class of job to be cast, which introduces one of the largest problems in the foundry. No definite temperature can be given to cast the 88:10:2 alloy. It is forced to vary with the size and nature of the work to be cast, but it is insisted that the range certainly lies between the figures previously quoted, 1,075 and 1,175 deg. C. for sand castings. All temperatures referred to were taken on a platinum—platinum-rhodium thermo-couple pyrometer.

## HEAT TREATMENT.

The practical value of "annealing" of castings in Admiralty gunmetal and kindred high tin alloys is not sufficiently realised. It is sometimes found that castings subject to steam or water pressure, although sound when tested in the rough state, after machining are found to sweat or weep under pressure. This trouble is probably due to slight structural weakness of the metal, and is more often to be found in the radius of flanges and at points of irregular thickness. When the casting has reached this stage it is a serious matter to have to scrap it, and any method by which it may be converted into a satisfactory state is worthy of attention. Primrose, in his book on "Admiralty Gunmetal," is quite enthusiastic about annealing, and the authors confess that it was after reading his remarks that they first turned their attention to it. They have so far only treated castings of medium size, and the treatment they adopted has been carried out in the ordinary low-pressure gas-annealing furnace. If such castings are annealed at a temperature of 700 deg. C. for about an hour, and carefully cooled out, they have known in many cases weeping to be entirely cured, and as an instance we can quote the following case of three complicated valve bodies in gunmetal containing 12 per cent. tin, which had to withstand a hydraulic test pressure of 2,500 lbs. per sq. in.; all three after machining weeped slightly on test, although there was no defect visible to the eye. One sweated at between 400 and 500 lbs. pressure, and the other two at 700 lbs. After giving them the annealing treatment described, all three withstood to the full test pressure of 2,500 lbs. without a sign of weeping. In another instance some half-dozen water-gauge fittings for boilers in an ordinary gunmetal all sweated at one point at about 90 lbs. pressure, but after annealing they all stood the test pressure of 350 lbs. successfully. Care must, of course, be taken to see that all overhanging portions of the casting are adequately supported when in the annealing furnace, for otherwise distortion is bound to take place.

It is not claimed that this treatment is an infallible cure for all castings that leak on test, as no annealing will close up holes in castings, but it is successful in the great majority of cases where a weep takes place under pressure.

In another direction annealing has its use. It is well known that it is far from easy to obtain sound homogeneous castings in gunmetal of round bars, say 2 in. diameter and upwards. Casting in cast-iron chills is a simple way out of this difficulty, and is, moreover, cheaper. It has the effect, unfortunately, of giving a much harder metal with a lower elongation, owing to the rapid freezing caused by the chilling action of the iron mould, and for this reason Admiralty gunmetal for test purposes cannot be cast in this way, as it fails to give the necessary elongation on test. If, however, the bars after casting are annealed in the same way as the sand castings mentioned before, they will then readily pass the Admiralty test. As an illustration of this some actual test results from pieces cut from the same bar in each case are given in the following table:—

TABLE III.—*Tensile Tests of Gunmetal before and after Annealing.*

| | As Cast. M.S. tons per sq. in. | As Cast. E. per cent. | Annealed M.S. tons per sq. in. | Annealed E. per cent. |
|---|---|---|---|---|
| 1 .. | 11.0 | 1.0 | 14.0 | 14.5 |
| 2 .. | 11.0 | 2.5 | 15.8 | 18.0 |
| 3 .. | 12.7 | 3.0 | 14.2 | 18.0 |
| 4 .. | 13.8 | 4.0 | 18.0 | 29.0 |

It is also interesting to note the results obtained from test pieces cast in dry sand; these were ordinary 1¼-in. square bars cast two on a gate, one of which was broken as cast and the other after annealing. Two casts were made, and the results are given in Table IV as follows:—

TABLE IV.—*Test Results on Dry-Sand Test Bars.*

| | As Cast, M.S. tons per sq. in. | As Cast, E. per cent. | Annealed. M.S. tons per sq. in. | Annealed. E. per cent. |
|---|---|---|---|---|
| A .. | 16.2 | 15.0 | 18.8 | 35.0 |
| B .. | 15.2 | 12.0 | 19.8 | 33.0 |

It will be seen that in every case given the improvement in the elongation is remarkable, and, in addition, it is accompanied by a marked increase in the breaking stress. It can be therefore safely deduced that the general strength of castings is substantially improved by annealing.

## CONCLUSION.

In conclusion the authors would like to state that their chief reason for submitting these remarks is to try and arouse interest among practical men. Finally, they wish to thank Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, and Mr. W. E. Walker, the General Manager of the Brass Department of the Company, for permission to publish the results of the experiments given.

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AT THE ANNUAL MEETING of Baldwins, Limited, a shareholder asked whether the proposed amalgamation with Nettlefolds was likely to materialise, but the chairman, Sir Robert Horne, M.P., replied that that was not a matter of which he knew anything, and therefore could not give an answer.

VICKERS, LIMITED, have received an order from the London, Midland and Scottish Railway Company for the construction of two cargo steamers for their Goole and Continental service. The steamers will be 240 ft. long, 35 ft. beam, and 16 ft. 4 in. in depth, with a speed of 13 knots. Messrs. Vickers have also secured the contract to repair and recondition the steamer "Ceaserea" for the Isle of Man Steam Packet Company.

# Institute of British Foundrymen.

## COVENTRY BRANCH.

### Discussion on Mr. Currie's Paper, "The Preparation and Testing of Moulding and Core Sands."*

#### Sand Preparation.

MR. A. HARLEY, commenting first on the very gratifying attendance, said it showed what a little propaganda work among members of the foundry trade could do. He had arrived at the conclusion that defective sand preparation was responsible for a greater percentage of scrap than any other cause whatever. The proper preparation of sand presented some difficulty where there were, as in many instances in Coventry, composite foundries; that was, foundries which dealt with about four different metals, and in the case of each metal turned out a large number of different classes of castings, all practically under one roof. They were very much aware of this difficulty owing to the troubles that occurred periodically, most of which he thought could be traced to sand. Of course, in the old days every moulder was an expert in judging sand. In his old days at Coalbrookdale a moulder of high class work would have been insulted if anybody but himself had been requested to prepare his sand. That was his own job, and a very important part of his work. While he did not put forward that this was a practice applicable to present-day mass production methods, yet it was worth noting that in those days, when the moulder knew exactly what he wanted, the result of this knowledge was that there was a very small percentage of scrap traceable to unsuitable sand. However, it was necessary nowadays, owing to the altered conditions of production, to have sand prepared for the moulder in bulk; and he was certain that the industry would be required to give a great deal more attention to the apparatus in use for this purpose. His view was that moulders of to-day should take a more intelligent interest in their work so far as the kind of sand they were using was concerned. Indeed, he might be exaggerating, but he might almost say that the average machine moulder would use mud if it were given him. Now if a moulder were able to judge sand when he felt it or after he had moulded one or two castings reported on any defect, it would form a very important check on the operations of the sand mixing department. Perhaps the most important developments during the last 15 years or so had taken place with regard to silica sand, and in his own foundry silica sand cores had been used for about that period with uniform success. He might confess that he had retained the binder with which he started, for he had tested innumerable artificial binders, and had given them up, because he had discovered on testing many of them that if they did what was claimed for them, the cost was invariably higher.

#### Sand Binders.

The binder he had used for years was the treacle soluble binder, and they could make all sorts of silica-sand cores with it, including a six-bore cylinder jacket, which was a fairly large cylinder. The only trouble that they had had, and eliminated years ago, was distortion. There were machines on the market which increased the ease with which these binders were mixed with silica sand, and to-day his firm used a mixer which did the work in about a tenth of the time taken by a man, and also did it better. If they were in the habit of using these sticky forms of binder mechanical means of mixing was a great advantage and ensured uniformity. He did not care for sea sand, and he noticed that Mr. Currie had remarked that Leighton Buzzard sand was not usually employed for core making. But years ago he himself found it so good that, like the man in "Punch," he had used no other. It was better than sea sand, and he had found this sand better graded and more uniform in grain than sea sand, with no lime content which might arise from broken shells. Mr. Currie had given a very practical Paper, and one that every foundryman should be interested in.

#### Experiences with Various Sands Detailed.

MR. DRAKE observed that as regards Mansfield sand being good for moulding, his experience was that it was a little too close. Wolverhampton sand he had found excellent. For cast iron, aluminium, brass and various other mixtures of metal he had seen none to equal it. He very seldom found any scab resulting. Something might usefully be said about coal dust in the preparation of mouding sand; it was a very handy material, and they could not do much without it in many cases, for it contributed to the making of really good castings. As to Leighton Buzzard sand, it was among the best, and had the merit of being uniform. He believed it could be had in grades from No. 1 to No. 8, but the first two were more fit for sand blasting. However, Nos. 5, 6 and 7 were very fine, and quite good. Among vegetable binders, he had found treacle extremely efficacious, but he had never yet seen fish oil used for the purpose without another ingredient. Perhaps patent brands of treacle were better, but he could assure them that if they worked the fish oil with treacle or some such binder they would obtain a harder core and one quite as porous, and at the same time avoid scab and blow holes.

MR. WILLIAMS asked what was the percentage of sand constituents for different sizes of castings and different kinds of castings, non-ferrous and ferrous. As regards binders, he thought the majority of them had heard of Glyso, which had been used in his firm's foundries for a number of years with very great success. It was a perfect binder for small cores. One feature about it was that when they came to extract the sand from the inside of the casting it disintegrated so easily that there was no trouble whatever in cleaning the casting.

MR. BEENEY wished to obtain information upon one particular point, because the lecturer had said that good porosity did not necessarily mean good permeability. At first sight it would seem that the sand which had large, well-rounded grains would possess good porosity and also the required permeability, and he did not quite see how the difference came about. Did it occur through the distribution of the binder, or was it due to some other factor?

#### Coal Dust and Weight of Castings.

MR. AXBY (a visitor) expressed thorough agreement with Mr. Harley as to scrap caused by sand. One firm making a very intricate casting for submarine cylinders, built up in five jackets all on top of one another, had tried to make it with several patent binders and different sorts of sands, but it was found necessary to go back to the old-fashioned core sand to avoid turning out scrap. In a shop where a good many change wheels and fly wheels in connection with gearing were made all sorts of sand were tried, and they had found nothing better than Mansfield sand. Regarding Mr. Drake's point about the use of coal dust, it was a question of the amount of metal to be poured into the mould. In castings weighing three or four tons, and also with change wheels for lathes, he had never used any coal dust. Change wheels were cast green, and no scrap was obtained. Moreover, they had perfect teeth. His experience had shown that they could make castings easier and with better results by adopting the old-fashioned methods, and, personally, he did not lay great store by these patent binders. A person who had considerable experience in these matters recently stated that patent binder sands were detrimental to the casting, and that he would defy any moulder to turn out as good a casting as regards its condition with any artificial sand as with old-fashioned methods. He would like to know whether this was really so or not. The lecturer had raised some interesting points, but he must say that the old moulders knew how to mix their own sand, and he wished this practice were followed to-day.

MR. DRAKE agreed that for making cast-iron fly

* This Paper was printed in our issue of December 13.

wheels, coal dust had to be eliminated, but pointed out that the castings were of a very heavy type. The coal dust which was near the metal burned into the sand, and therefore scab resulted.

MR. AXBY replied that it was not mixed sand. He was against using coal dust in any sand that had to be dry and porous, because it was unnecessary. The only reason for putting in coal dust, which must be done sparingly, was because if the sand happened to be slightly wet it helped to take away the steam. He had tested it many times, and had found that it was not required in half the cases in which it was used. For if coal dust was added to sand which was dried what good could it do, seeing that it only came out again as ash. However, to face with Mansfield sand would be an expensive job.

MR. ELSON urged that much depended on the efficiency of the moulder. It did not matter what preparation of moulding sand or core sand one used if the moulder was inefficient; for as to coal dust, it was certainly useful in getting the steam away, and he asked them to think what would happen if they did not provide for this. In making cylinders in green sand they never knew what it was to get scab from one week-end to another. A great deal also depended on the material. If they had a good preparation of sand not evenly rammed or not properly blended they would not obtain a sound casting.

### Sand Mills and Paddle Machines.

MR. C. H. JUDD observed that there was an interesting case that week which had come under his notice of mixing silica sand with binders: one in the old style of the pan mill and the other in the modern paddle machine. The same quantities of Leighton Buzzard sand, with linseed oil and treacle, were used. In the pan mill the sand came out perfect for core making in the sense of binding and holding in of the core box, but in the other machine the sand came out and would not bind together. In fact, if it were squeezed in the hand it fell to pieces. In the first case there was quite a good bind and a perfect core. This seemed to favour the old-fashioned method as being better to a certain extent than the modern method, but he must say that the modern machine apparently did its work satisfactorily originally. He wondered if the lecturer had had any experience of these machines in turning out core sand and of the trouble which his foundry had come across only that week.

MR. C. DICKEN, M.I.M. (Branch-President), referring to the methods of the old moulder, recalled the case of an old craftsman when he was apprenticed who made it his practice to mix his facing sand for moulding on a Saturday ready for the following week's work. That moulder always believed in letting the sand stand by for a time, and covered it with a bag, the idea being that it would then become moistened throughout equally and not be likely to fall away. So far as treacle was concerned, he mentioned that his father and grandfather used a lot of sugar before these modern improvements were introduced for coring purposes. The Wolverhampton sand which had been mentioned was really Wombourne sand, which was obtained from just outside that town, and it could well be compared with Stourbridge sand. The lecturer had placed several mixing machines on the screen, and he wondered whether any of them could take the place of the old sand mill, because he noticed that one type was a mixer and another type was a refiner, and in some instances they could not do without refining the sand. In the case of the transverse test, using a core 1 in. sq. by 8 in. long, was the object to ascertain the hardness of the core, because surely that was regulated by ramming or the moisture content? For cores made on a jolting machine, the core boxes were fastened on, and the moisture in the sand or the ramming depended on the number of jolts, which thus regulated the hardness of the core. They found that if the moisture was a little too much the core would come out heavier. Each core was weighed, and if it was over ¾ lb. they could rely upon it scabbing, but if under good results could be guaranteed. The lecturer had evidently taken great pains, and put some real hard work into his Paper.

### The Author's Reply.

MR. CURRIE, replying to the discussion, thought that most of them would agree that the preparation of sand by a man always on the job was much better than leaving it to the moulders to make the different mixtures when they thought fit. By that method greater production was obtained, and they could scarcely expect to trouble the moulder with the job when production was so important. Their work as moulders was to make moulds, not to mix sand. With machine moulding becoming universal they were forced to find a quicker method than the old one. He agreed with Mr. Harley as to the number of faulty binders on the market. He had tested a good many, and his experience was that by doing this they could soon discover which was the best material for their particular purpose. With binders such as Mr. Harley used he found that distortion was less likely to occur, as mixtures in the green state were stronger than when using oils. He perhaps needed to qualify the statement that Leighton Buzzard sand was not usually employed for core making. For fine work they needed not the rough grain sand, but the finer material. As to Mr. Drake's point about fish oils, they were not usually used alone, but as an admixture with linseed oil. There were certain difficulties in the mixing of fish oil in water soluble binders, such as treacle, and it was far better to mix different oils than to mix two different class of binder like water soluble binders and oil. For binders for ferrous and non-ferrous metals he preferred a dry binder like resin for the latter, but for iron he required one rather stronger, which would produce a core to resist strain, and this was more likely to be secured by using linseed oil or treacle. Mr. Beeney had commented on the difference between porosity and permeability; the two were similar, but a core might be very porous, indicated by the density, and yet not have a high permeability figure, as understood by resistance to free air passage of gas due to angularity, irregular grain size. Alluding to the speaker who preferred old-fashioned mixtures to new-fangled ideas, Mr. Currie pointed out that silica sand eliminated many rods and grids, etc. It was much stronger, and was an important factor in the case of rapid production. Further, it would stand more handling than the old style of mixture, and he might mention that nowadays they were not over-careful in the way in which they handled cores. The use of coal dust was not universally necessary in heavy green sand work; and he said that it only took effect just outside the mould surface. They could use a better facing sand for the purpose, but if they did it must be well vented all round. Mr. Elson had raised the question of the proper mixing of sand and the efficiency of moulders. The moulder with a shovel could not do so well in the sand mixing department as could proper machines made specially for the job. He endorsed his remarks completely. Then Mr. Judd had stated that the pan mill had been found better for mixing silica sand. Possibly they did get better results with a large grain sand like that of Leighton Buzzard. He used a paddle mixer, and with a small grain sand like sea sand there had been no difficulty in producing a very good mixture. A pan mill was much slower in its operation: that was his reason for using other mixers. It was necessary if they were making a steel moulding sand or a synthetic sand to use a pan mill: but if they were using a sand such as Mansfield in conjunction with other sands for iron, and large quantities were required, then they wanted something quicker.

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SIR ROBERT HORNE will, we understand, be chairman of the National Smelting Company, the other directors being Sir Cecil L. Budd, Sir John Davies, Mr. F. A. Govett, Captain Oliver Littleton, Mr. S. C. Magennis, Mr. William S. Robinson, and Sir John Roper Wright. In connection with this scheme it is stated that an issue of £1,500,000 7 per cent. debentures is to be made by the National Smelting Company, which, as we have already pointed out, will acquire the zinc smelting plants at Avonmouth and Swansea, together with 4,000,000 Burma Corporation shares. It is understood that Baldwins, Limited, the British Metal Corporation, and influential people associated with zinc mining and smelting propositions in Australia are interested, and the Government plant at Avonmouth is said to be included in the project.

# The Foundry Cupola and Mechanical Charging.*

By A. A. Liardet, M.I.Brit.F.

(*Continued from page* 543.)

### The Mechanical Charging of Cupolas.

The mechanical charging of cupolas is by no means a novelty. It is being carried out successfully in America, Germany, France and Belgium and also to a limited extent in this country

In spite of this fact, in each of these countries there still exist practical foundrymen of wide experience who claim that mechanical charging of cupolas cannot give such good melting results as the older method of hand charging.

The author is of the opinion that these gentlemen must have some very good reason to back up their opinions. Probably this reason can be traced back to an experiment carried out with some form of mechanical charging apparatus that was not properly constructed and therefore gave bad results.

There is no reason why a cupola should not be charged by mechanical means to give at any rate results equal to those of hand charging, and under certain conditions better and more consistent results can be obtained, as the human element is to a great extent eliminated.

It is difficult to conceive that an operator can throw the pig-iron into a cupola in such a way that each pig lies beside its neighbour and forms a perfect layer, especially when the pigs have to be thrown into the furnace door from which hot gases and even flames may be issuing.

As a theoretical argument the possibility of doing

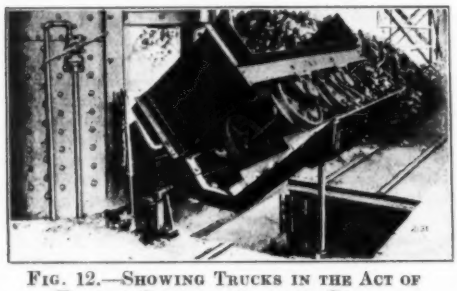

FIG. 12.—SHOWING TRUCKS IN THE ACT OF TIPPING CONTENTS INTO THE CUPOLA.

this can be advanced, but anyone who has spent some time on a foundry cupola platform while the cupola is in blast will have noticed that to avoid the heat of the gases issuing from the furnace the operator generally has become skilled in throwing the pig-iron through the furnace door while his back is turned towards it.

### Methods Used.

The mechanical charging of cupolas may be performed in several ways. First by the inclined skep hoist which elevates small trucks from the ground level and tips fuel and coke directly into the cupola. This system is applicable for small or medium-sized melting units and does away with the necessity of a charging platform.

Secondly, by elevating small wagons containing the necessary charges by means of a hoist to the platform level. The trucks run on rails, and by means of turntables can be brought directly opposite the charging door of the cupola, where their contents are tipped directly into it.

Thirdly, by an overhead runway system having electrically operated hoisting gear which lifts the material directly from the stockyard and delivers it directly into the cupolas.

When a new foundry is being constructed it is well worth taking into consideration the possibility of arranging the railway siding upon which the incoming material arrives, so that the end at which the material is discharged is on the same level as the charging door of the cupolas.

In some cases the nature of the ground upon which the foundry is erected makes this a simple matter to accomplish, but under any conditions it is not a very difficult matter to provide for a siding gradually rising away from the railway track to the ultimate destination of the trucks.

The metal and fuel arriving by this siding can either be dumped directly from the railway truck by means of an overhead travelling crane into the

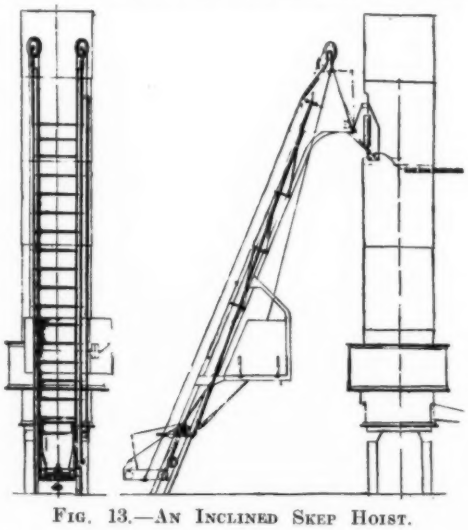

FIG. 13.—AN INCLINED SKEP HOIST.

stockyard or placed into small wagons running on rails leading to the actual charging door of the cupolas.

Several methods can be adopted for the actual tipping of these trucks; the truck itself may be of the tipping type. When it arrives at the predetermined point it can be tipped either by hand or by a small pneumatic lift placed immediately over it so that its contents drop into a chute leading directly into the cupola.

Another method which is used pretty generally in the United States is to have a pneumatically operated hinged platform immediately opposite the charging door, the truck being pushed on to this, locked in position and is then pushed over by the

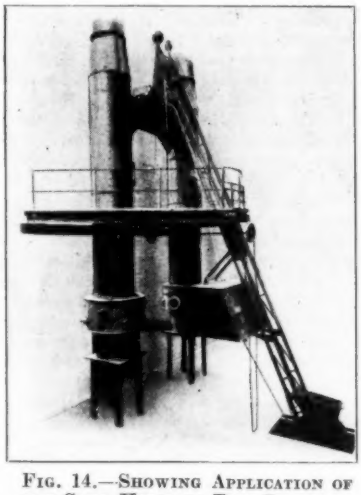

FIG. 14.—SHOWING APPLICATION OF THE SKEP HOIST TO TWO CUPOLAS.

pneumatic cylinder to such an angle that its contents are tipped into the cupola.

This arrangement is illustrated in Fig. 12.

The author is aware that there are several foundries in this country so situated that the materials for their cupolas are delivered from the railway siding on to the actual platform level, but very few of them appear to take full advantage of this labour-saving condition by handling the

* A Paper presented to the London Branch of the Institute of British Foundrymen, Mr. V. C. Faulkner presiding.

material directly from the trucks into the cupolas by mechanical means. The majority still appear to prefer to stack the material on the platform and afterwards charge it by hand into the cupolas.

To return to the cupola installation where the material is brought either by railway wagon or by road vehicle to the foundry floor level, we find that the usual practice is to stack the pig-iron according to the various qualities in the stockyard. It is needless to say in passing that the fuel should be kept under cover to avoid absorbing unnecessary moisture from the weather.

In this case, if we decide upon mechanical charging, we then have the choice of the three methods mentioned earlier in this Paper of transporting the material into the furnace itself.

Undoubtedly in the case of the small- or medium-sized foundry having not more than two cupolas, the only method which would not be prohibitive in first cost is the inclined skep hoist.

Fig. 13 illustrates an apparatus of this nature operating in connection with a cupola of 4½ tons capacity per hour. The hoist itself, which is operated by an electric motor, is fitted with a cradle running in the angle-iron framework.

This carriage is fitted with guiding rails and a locking device, so that trucks fitted with either flanged or flat wheels according as it is considered desirable to run them on a flat surface or rails,

FIG. 15.—A BRITISH MECHANICALLY-CHARGED CUPOLA PLANT.

are loaded with the necessary pig-iron and fuel in the stockyard, pass over a weighbridge to check the amount, and are then wheeled into the cradle. The hoisting mechanism then elevates the cradle with the truck and tips the contents of it directly into the cupola.

From Fig. 13 it will be seen that a special form of hopper is fitted to the cupola which causes the contents of the truck to slide slowly into the cupola, at the same time spreading it so that there is no tendency for the charge to heap up against either one or other side of the cupola lining.

It will, of course, be obvious that with an apparatus of this nature it is not possible to charge the cupola right up to the level of the charging door, as, were this done, the last charge would lie at an angle in the cupola, and consequently as it worked down subsequent charges would also be at an angle, causing the alternate layers of coke and iron to partially mingle and not lie horizontally upon one another.

When the skep hoist is supplied with new cupolas, the charging door is arranged at a greater height than standard practice. Where this type of machine is installed with existing cupolas it is usual to cut a charging door at a higher level than the existing door to maintain the charge at the original working height. It will be observed that the hoisting mechanism forms part of the machine, and is so arranged that one simple hand lever operates the ascending and descending movements of the cradle, and when let go automatically puts on a brake holding the cradle in any position.

When the bucket tips at the top it automatically brings the lever to the central position, applying the brake.

This size machine has a capacity of 6 cwts. of iron and ½ cwt. of coke so that to keep in blast a cupola of 4½ tons of iron per hour, about 33

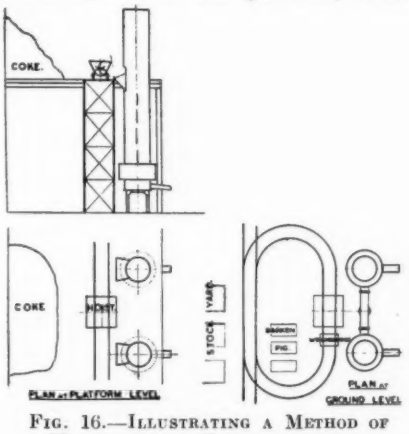


FIG. 16.—ILLUSTRATING A METHOD OF MECHANICALLY CHARGING TWO OR MORE CUPOLAS.

journeys have to be made, or one journey in every 1¾ minutes.

Several of these skep hoists are working satisfactorily in this country, and it will be obvious that they represent a saving in labour and a better control over the charging of the cupola. Fig. 14 shows its application to two cupolas, and Fig. 15 a British installation.

The second method of mechanical charging is illustrated in Fig. 16, and the author is indebted to Monsieur Thomas, of the firm of A. Piat & Company, of Soissons, France.

It will be seen that this system is very similar to the skep hoist charger except that an ordinary hoist is used to elevate the charges in the flanged wheel trucks, and when they arrive at the platform level they are moved along rails provided to receive them, until they are opposite the required cupola, when their contents are tipped directly into the furnace door.

An oval-shaped truck is provided on the ground level, which enables the trucks to move in one direction when coming from or returning to the stockyard.

Another interesting method of handling these laden trucks on the platform is shown in Fig. 17, which has been taken from a well-known American catalogue. The author has seen this method in successful operation in the States in several plants.

The loaded trucks when arriving at the platform level are placed on to an electrically-operated transporter having on it a turntable. This trans-

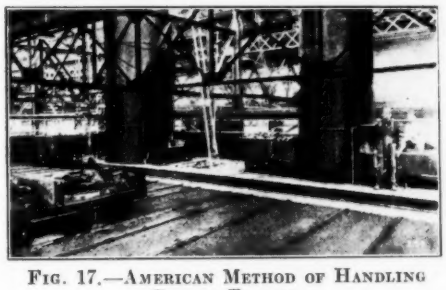

FIG. 17.—AMERICAN METHOD OF HANDLING CUPOLA TRUCKS.

porter moves the trucks opposite one or more sets of rails, which lead directly to the sides of the cupola charging doors and also to other rails provided on the platform for keeping loaded trucks in position for rapid charging.

In these plants the coke was not handled in the same way, but was stored in hoppers at a higher level than the cupola platform, and by means of a specially arranged shutter the correct quantity of

coke was liberated from these hoppers and allowed to fall directly into the cupola charging doors.

The next method of charging cupolas, which is certainly expensive to instal but ensures the mechanical handling of the material directly from the stockyard to the cupola, is illustrated in Fig. 18, which is also taken from particulars supplied by Monsieur Thomas, of Piat et Cie., who has supplied the following particulars:—

"Tackling the problem by an electric overhead runway is, in my opinion, the most satisfactory, yet at the same time is the most expensive. Fig. 18 shows how we apply it to the charging of the cupolas in our steel foundry. It is used for two distinct purposes: (1) Discharging and storing coke in bins, the bottoms of which are placed on the first stage platform; (2) the charging of the cupolas on the second stage. The coke railway wagon which has to be discharged is at (A), two workmen throw the contents by means of a coke fork into the tub (B), which has a capacity of 1½ cubic metres. When this is full, a workman, by operating the controller (C) raises the tub to the level of the overhead beam, and at the same time sets it moving in the direction of the arrow. The moment the tub passed a selected point (H) on the bin being filled it comes in contact with an adjustable arm which causes it to tip.

"As soon as the coke is emptied the bucket

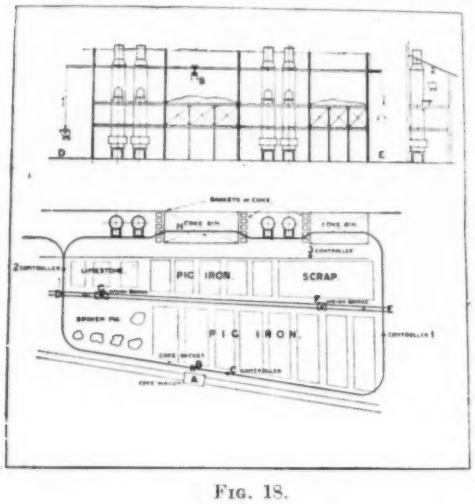


FIG. 18.

returns to its normal position and continues travelling on the runway until it arrives at the point it started from, where by again operating the controller it descends to the ground level in order to be refilled. Thus, the discharging of a wagon containing 20 tons of coke is readily carried out by two men in 45 minutes and with the minimum amount of exertion since the top of the tub is exactly level with the bottom of the wagon.

"The charging of cupolas is carried out as follows:—

"A small wagon filled with pig-iron—by methods which we shall discuss later—is waiting at the ground level at the despatching position D, the workman on the second stage charging platform operates a controller (2) which causes the hook of the electric winch to descend, this winch being attached to a carriage on the overhead runway, and having been brought to rest immediately over the small wagon. The workmen in the stockyards on the ground floor hooks on the wagon, which is then raised to the level of the overhead girder by another operation with the controller (2). Then the electric winch with its load starts automatically to move along in the direction of the arrow, and finally is automatically stopped in front of the cupola which is in blast. The cupola charger operates a small lever attached to this cupola which tips the wagon and allows its contents to be charged directly into the cupola, then by the further operation of one or other of the controllers on the platform according to which cupola is in blast, the empty wagon is carried forward on the run-way and finally stops at B opposite the receiving position.

"The second workman employed in the stockyard by operating controller (1) causes the empty wagon to descend. This wagon is fitted with wheels and it drops on to the narrow railway track B A, while the hook when freed from the wagon is elevated by the electric winch, and the whole travels on the overhead run-way until it arrives immediately opposite the despatching position, and so on.

"Examine the work actually carried out in the stock-yard and on the charging platform, and, assuming that costing operations only take place in the afternoon, the morning is confined to the preparation and the storage of the metal and fuel required for melting. In the stock-yard two men are employed breaking up the necessary pig-iron in front of each stack by means of an electrically-operated pig-breaker. These are carried to the storage ground for broken pig-iron by means of an electric locomotive crane fitted with an electric magnet. The same workmen discharges the coke and pig-iron from outside wagons, as has been previously described.

"On the charging platform a man is employed filling a certain number of flat baskets with coke, which he has previously lifted out of the storage bins, and he places them at D close to the cupolas. He also assists his two mates in the stock-yard in their work; this man is in charge of the working of the cupolas.

"During casting, the workmen in the storage yard receive the empty wagon at E, run it over the weigh bridge for the scrap iron at F, where

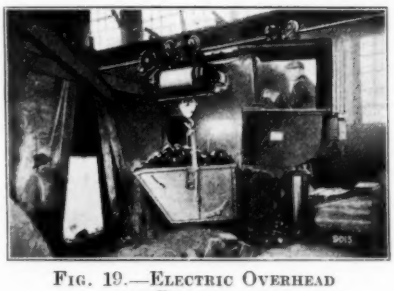

FIG. 19.—ELECTRIC OVERHEAD RUNWAY.

the necessary quantity of scrap iron is charged into the wagon, then on to a multiple arm weighing bridge at G, where the charge is completed with the broken up new pig-iron, selected runners, and the necessary weighed out flux, and finally take it to the position at D. One of these men then hooks on the wagon to the electric runway, whilst the other returns it to the receiving position E to receive the empty wagon, and so on.

"The workman on the platform receives the wagons one after the other, empties them into the cupola, and charges in the necessary fuel by hand which he has prepared in the morning.

"At the side of each cupola on the charging platform, as well as in the foundry under the air belt, are two kinds of clocks, electrically connected, the faces of which are marked off in graduations carefully calculated from the holding capacity of the cupola. Before starting melting, the foreman marks on this indicator the different qualities of iron which are required. During melting each time the charge is tipped into the cupola, the workman on the platform presses a button, which makes the needle advance one division on each of the clocks. He then is always aware at any moment of the number of charges which have already been tipped in, and he can also check the nature of the iron which is being dealt with. By the same way, in the foundry, any member of the staff, either the manager, foreman, or moulders, know at any moment the kind of metal which is contained in the hearth of the cupola."

In some installations where this runway system is in force the electric lift handling the charging buckets is fitted with a cabin in which an operator is seated—very much after the style of the luggage transporter in Manchester Victoria Station. This method is illustrated in Fig. 19, which is also taken from a well-known American catalogue. From this it will be seen that the bucket actually enters through the charging door of the furnace and the contents are then tipped.

# The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

**Patent No. 5049.**

THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

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## JAMES EVANS & CO., BRITANNIA WORKS (MANCHESTER), LIMITED.

## BLACKFRIARS, MANCHESTER.

# IRON AND STEEL MARKETS.

## Pig-iron.

**MIDDLESBROUGH.**—Business in the Cleveland iron market over the close of the year has been virtually non-existent, and very few transactions may be expected to materialise during the current week, which will be mainly devoted to the final holiday celebrations. In market circles, however, the spirit of optimism prevails as regards the immediate future, the revival of home demand for pig-iron giving an assurance of growing strength in consumption which should ensure an expansion of furnace output, giving employment to plants now idle. In confirmation of this view, as Sir Arthur Dorman pointed out at the annual meeting of Dorman, Long & Company, Limited, there is a great disparity between the production of pig-iron and the output of steel in this country, and the question of bringing up the former to the required level is now urgent owing to the exhaustion of the stocks of war scrap and the probability of something like a famine in scrap material. The export section of Tees-side pig-iron continues in a somewhat disappointing volume, but there is also a prospect of expansion in this direction, the returns for the past month comparing not unfavourably with the total for November. Prices are steady and practically unchanged, though, perhaps, there is a shade of temporary weakness owing to the holidays. No. 1 is 106s. 6d. to 107s. 6d., No. 3 G.M.B. 100s., No. 4 foundry 98s. to 99s., and No. 4 forge 97s. to 98s. per ton.

The market for hematite continues firm and steady at late prices. For East Coast mixed numbers 102s. 6d. is a minimum figure for early delivery, and some makers are asking 1s. per ton more. The premium for the No. 1 quality amounts to fully 1s. per ton. On the North-West Coast similar conditions may be noted, with prices firm at the old rates, Bessemer mixed numbers being quoted at £5 15s. per ton, delivered at Glasgow and Sheffield, and £6 to Birmingham.

**MANCHESTER.**—There having been only a partial resumption of work at the local foundries this week, the demand for pig-iron has been on a very diminished scale, and as most consumers have already bought forward in considerable quantities, it will be well into the New Year before markets are restored to normal activity. Sellers of foundry quality pig are, however, quite firm and are quoting 95s. on trucks for Derbyshire No. 3, which is now looked upon as a low price. Whether or not the price will be generally advanced by 2s. 6d. per ton in the immediate future cannot be said with any certainty, but this may not be thought unlikely in the present condition of the trade.

**THE MIDLANDS.**—Throughout this area, and especially in South Staffordshire, most consumers' works are still out of action, and consequently movements in the pig-iron markets are without special significance at the moment. Stocks at furnaces have, of course, been accumulating during the holidays, and instances are reported of smelters shading prices to a slight extent in consequence, but with full prices at present levels such conditions can only be regarded as temporary. There seems to be no doubt that coke is scarce, and that oven owners again find it necessary to put up prices. So far it has not amounted to much, and it is to be hoped that it will not, for there is no doubt that the way fuel forced up the markets generally last year had much to do with the disappointing collapse that occurred then. Quotations: Northamptonshire No. 3 foundry, 92s. 6d.; Derbyshire No. 3 foundry, 95s.; all net f.o.t. furnaces.

**SCOTLAND.**—With markets closed during the week for the New Year festivities, both buying and selling of pig-iron has been temporarily suspended, occasional offers by merchants at slightly easier values failing to attract consumers to any extent. Makers, however, having good order-books, are looking on with equanimity and maintaining their prices, the general quotation for No. 3 remaining at 107s. 6d., f.o.t. furnaces. A few people are taking the view that we are going to see an easier position in fuel owing to the Ruhr improvement, but this may be offset by the greater expansion in consumption in the home market as the result of the large orders which have been placed over recent weeks.

## Finished Iron.

The final market of the year at Birmingham last week was, as might be expected, extremely quiet, and it will probably be another fortnight, when the quarterly meeting is held, before the exact position of the finished iron section can be definitely ascertained. It is, however, gratifying to report that in most respects the industry is in a more satisfactory position than it has been for months. The only disquieting circumstance is that foreign common bars are again being offered at prices much below those of local producers, prices which, of course, they are unable to accept. That, however, is the thing to be expected if there is any real agreement to restart work in the Ruhr. For the time being, however, though business is quiet, prices are quite firm.

## Steel.

The outlook in the steel industry in the new year has fortunately brightened to a very considerable extent by the placing of extensive orders for railway material and engineering contracts, upon which work will be started on the termination of the current holidays. At Sheffield there is a fair volume of business passing in acid billets, but basic billets appear to be rather less eagerly sought, and the quotation for soft qualities shows a weakening tendency. In alloys, a number of Continental inquiries for ferro-manganese have been received, and American business is improving, but the home trade has naturally been at a standstill during the week. Prices are unaltered, but an advance may be notified at any moment, order books recording some fair business over the next couple of months. The tin-plate market has been considerably quieter, and prices do not appear to be quite so firm. The turnover, nevertheless, has been very fair. There are a few second-hand parcels about, and these have been dealt in at 6d. above the basis price of 23s. 9d. The recent heavy sales are being reflected in the shipments. France, Italy, and Holland have been in the market, and there has been some buying from India and Far and Near East.

## Scrap.

The majority of consumers' works having suspended operations for the time being, there is little fresh to record with regard to the markets for scrap material. On Tees-side a shortage of material is reported, and with the renewed activity in the steel trade values look like remaining high with, if anything, a further moderate upward tendency, though no sharp advances are looked for. The following are current prices, all delivered works: Heavy sheet scrap, 95s. per ton; heavy cast iron (machinery quality), 97s. 6d.; ditto (ordinary), 93s. 6d.; heavy steel turnings and cast-iron borings, each 72s. 6d.; heavy wrought-iron piling scrap, 97s. 6d.; heavy forge, 110s. to 115s. per ton. In the Sheffield market the important steel orders which are now coming along from various sources will help to keep the scrap market firm for the time being. Any good heavy steel material for melting does not long remain on offer and fetches anything from 100s. to 105s. delivered. With so many electric furnaces out of commission the demand for turnings is good without being keen. Heavy wrought iron continues to sell most readily, also the various classes of iron scrap. There has been no further movements in quotations.

## Metals.

**Copper.**—Since the resumption of business after the holidays, business in the standard market has been without movements of special importance, with the exception, perhaps, of increased firmness in electrolytic metal. American producers have shown no inclination to encourage business by a policy of price cutting, and the feeling has undoubtedly gained ground that some curtailment in production is taking place in the States, thus accounting for the continued confidence of producers. The undertone of the American market is clearly much firmer than it was some time ago, and at the present time is influenced very little by the course of the London standard market. Current quotations:—*Cash*: Thursday, £61 10s.; Friday, £60 17s. 6d.; Monday, £60 17s. 6d.; Wednesday, £61 5s. *Three Months*: Thursday, £62 7s. 6d.; Friday, £61 12s. 6d.; Monday, £61 12s. 6d.; Wednesday, £62.

**Tin.**—Although buying in the standard tin market has been, for obvious reasons, on a more restrained scale of late, there has been no weakening of the general position, and a probable small increase in home stocks may be attributed to diminished consumption during the recent holiday season. Advices from the East report that after recent heavy clearances holders in that market have been more reserved. The Straits has sold moderately following the general trend of the market. America is reported to be quietly accumulating, though not taking an active part

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**MARKETS.**—*Continued.*

in the open market. The demand from South Wales has been restricted by the approaching holidays, and Continental business has been very small. Current quotations :—*Cash* : Thursday, £235 10s. ; Friday, £232 10s. ; Monday, £233 15s. ; Wednesday, £237 2s. 6d. *Three Months* : Thursday, £236 15s. ; Friday, £234 ; Monday, £235 5s. ; Wednesday, £238 10s.

**Spelter.**—A rather more active tendency is to be noted in the market for this metal, an improvement due to the ready absorption of prompt supplies, an advance in price in America, and the small tonnage offering on the Continent. Current quotations :—*Ordinary* : Thursday, £32 17s. 6d. ; Friday, £32 15s. ; Monday, £32 17s. 6d. ; Wednesday, £33 3s. 9d.

**Lead.**—In the market for soft foreign pig home consumers appear to be well covered for their immediate requirements, but with no slackening in their trade, when buying does again become a necessity, it certainly looks as if prices will rise higher. The price of lead in America is now above the parity ruling here, and it may be that the States will endeavour to buy back the lead which has been sold here. This possibility, of course, lends further strength to the market. Current quotations :—*Soft foreign (prompt)* : Thursday, £30 10s. ; Friday, £30 7s. 6d. ; Monday, £30 7s. 6d. ; Wednesday, £30 12s. 6d.

## Obituary.

MR. J. HENRY, of Joseph Henry, Limited, Manor Road Foundry, Holbeck, died on December 10, aged seventy-eight.

MR. B. BUTTERWORTH, general manager of Oldham & Son, Limited, engineers, of Hyde Road, Denton, died recently at Manchester, aged 42.

MR. A. C. MORRIS, joint managing director of Heaton & Dugard, Limited, Shadwell Street Rolling Mills, Birmingham, died recently in his 49th year.

MR. W. R. MAGUIRE died recently at his residence, Tower Hill, Dalkey, Dublin. He was chairman of Maguire & Gatchell, Limited, engineers, of Dawson Street, Dublin.

MR. JAMES HOLT, who died recently at his residence, Holly Bank, Walmersley Road, Bury, was one of the founders of the firm of Edward Kempster & Sons, Limited, Borough Brass Works, George Street, Bury. The deceased gentleman was in his 70th year.

MR. F. J. BLOOMER, the works manager of the Mond Nickel Works, Clydach, near Swansea, died on December 21. The deceased, who was 55 years of age, was at the works the previous afternoon, and appeared to be in good health. He had been works manager for 23 years.

MR. ARTHUR HAMILTON, of Hamilton & Sons, Limited, Victoria Foundry, Cardiff, died on December 28, under tragic circumstances. The deceased gentleman, who was well known in iron and shipping circles throughout the country, established the Victoria Foundry eight years ago, and prior to that was manager of the Vulcan Foundry at Cardiff.

MR. JAMES MILLAR, who has died at his residence, Laurelbank, Grangemouth, was one of the oldest shipbuilders in Scotland. He helped to build the old "Black Prince," the second iron vessel built on the Clyde by the Admiralty. He also built a number of light craft at Greenock. After this he held the position of manager of a shipyard in Cork Harbour, the present proprietors being Furness, Withy & Company. After a period in Canada he returned to this country and secured the position of manager of the shipyard in Grangemouth, which he held for about 18 years.

MR. DONALD M. KING, joint managing director of David King & Sons, Limited, Keppoch Iron Works, Possilpark, Glasgow, died suddenly on December 23 at his residence, 12, Kelvinside Gardens North, Glasgow, aged 63. Mr. Donald M. King had been associated with the concern from its inception in 1874, when the business was established by Mr. David King, senr., and Mr. John King, J.P., now chairman of the National Light Castings Association. In 1885, together with his brothers, Mr. David King and Mr. Robert King, he was assumed a partner in the firm. In pursuance of the development of the firm, Messrs. D. King & Sons in 1892 opened a branch established in Leeds, under the name of King Bros., and appointed Mr. Donald M. King as manager, which position he retained for over 20 years. On Mr. John King assuming the duties of chairman of the N.L.C.A. in 1911, Mr. Donald M. King returned to the works at Possilpark, Glasgow, in 1913, to take up duties there as joint managing director. He took a very active interest in the development of the business, and was studying a new system of production at the time of his death. Mr. King was very widely known in business circles. Mr. King caught a chill on December 3 and ventured out too soon to record his vote on December 6. Unfortunately, a relapse set in, which proved fatal a fortnight later.

## Company News.

**Falkirk Iron Company, Limited.**—Interim dividend, 3½ per cent., less tax, on ordinary.

**Broughton Copper Company, Limited.**—Interim dividend, 2½ per cent. actual on ordinary.

**Excelsior Metal Sales Company, Limited,** 177, Fleet Street, London, E.C.—Capital £6,600 in £1 shares.

**Hill's Dry Docks and Engineering Company, Limited.**—Loss, £16,720; brought forward, £17,200; carried forward, £480.

**Philip Shepherd & Company, Limited.**—Net profits, £5,709; brought in, £8,711; ordinary dividend, 10 per cent. per annum; carry forward, £5,680

**Gibbons (Dudley), Limited.**—Final preference dividend, 3½ per cent., second interim dividend, 3½ per cent. upon ordinary shares, both free of tax.

**Hindle, Son & Company, Limited,** Union Engineering Works, Haslingden.—Capital £15,000 in £1 shares (5,000 deferred). Engineers.

**Honos Works (London), Limited,** 10, New Broad Street, London, E.C.—Capital £100 in £1 shares. Machinery manufacturers

**Metal Treatment Company, Limited,** Fitzalan House, Arundel Street, London, W.C.—Capital £2,000 in £1 shares.

**Bier & Saxton, Limited,** Devons Road Station, L.M.S. Railway, Bromley-by-Bow.—Capital £1,000 in £1 shares. Metal merchants. Directors: A. H. Saxton and I. Bier.

**Glebe Manufacturing Company, Limited,** 5, Guildhall Chambers, 31, Basinghall Street, London, E.C.—Capital £10,000. Founders, mechanical and electrical engineers, etc.

**John Cox & Sons (Metals), Limited,** Leopold Foundry, Hick Street, Birmingham.—Capital £2,000 in £1 shares. Directors: A. D. Keeling, J. H. Cox and E. Cox.

**Lanes Lead Patents, Limited.**—Capital £500 in 1s. shares. Permanent directors: H. Edmunds (managing director and chairman), C. Lane, H. W. Lane and J. J. Pritty. Solicitors: Claremont, Haynes & Company, Vernon House, Sicilian Avenue, London, W.C.

**Lysaght's (Exports), Limited,** St. Vincent's Iron Works, Bristol.—Capital £10,000 in £1 shares, to acquire the business of John Lysaght (South Africa), Limited, and to carry on in the Cape Province and elsewhere in South Africa the business of iron and steel manufacturers, etc.

**Millom & Askam Hematite Iron Company, Limited.**—Accounts for two years ending September 30, 1922 and 1923, not ready for presentation, in consequence of amount due for taxation not being settled; formal meeting only on December 31; dividend on preference for half-year ending September 30.

**William Bailey (Birmingham), Limited,** Victoria Works, Weaman Street, Birmingham. — Capital £33,000 in £1 shares, to adopt an agreement with G., W., S., F. H., Robert, H. A., Roland, Harry, Harold and May Bailey and Eliza Manning. Stampers, founders, engineers, etc.

## Contracts Open.

**Droitwich,** January 5.—Four-inch cast-iron pipes and specials, for the Corporation. Mr. W. H. Wise, engineer and manager, Gas Works, Droitwich.

**Droitwich,** January 5.—400 lineal yards, more or less, of 3-in. cast-iron British standard coated water pipes and specials, for the Corporation. Mr. H. Hulse, borough surveyor, 105, Friar Street, Droitwich.

**Littlehampton,** January 9.—1,300 lineal yards of 4-in. diameter cast-iron water mains; also valves, hydrants, and other fittings, for the Urban District Council. Mr. L. G. Dashper, engineer and surveyor to the Council, Town Offices, Littlehampton.

**Markyate, Beds.,** January 14.—Provision and laying of approximately 550 yards of 4-in. cast-iron water main, for the Hemel Hempstead Rural District Council. Mr. T. H. Lighbody, 16, Alexandra Road, Hemel Hempstead, Herts.

**Northam, Devon,** January 1-8.—Provision and laying of about 4½ miles of 6-in. cast-iron pipes, for the Urban District Council. Mr. W. J. Barnes, clerk, 24, Bridgeland Street, Bideford, Devon. (Fee, £3, returnable.)

**Cowplain, Hants.**, January 7.—Providing and laying about 1,950 yards of 6-in. cast-iron water mains, also 900 yards 4-in. and 2,800 yards 3-in. ditto, etc., for the Catherington Rural District Council. Mr. G. C. Vernon-Inkpen, 40, Commercial Road, Portsmouth.

**Haywards Heath,** January 18.—1,750 tons of cast-iron socket pipes and specials of 18 in., 12 in., 9 in., 6 in., 4 in., and 3 in. diameters, British standard specification, for the Mid-Sussex Joint Water Board. Mr. F. Martin, engineer, Waterworks Offices, Boltro Road, Haywards Heath. (Fee, £2s 2s., returnable.)